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FRANCIS PRESERVED LEAVENWORTH.

By WILLIAM O. BEAL.

Francis P. Leavenworth was born near the Ohio River at Mount Vernon, Indiana, September 3, 1858. His parents were Seth M. and Sarah Leavenworth. After obtaining his preparatory education in the public schools he entered the University of Indiana from which he received the B. A. degree in 1880. In later life he often expressed his satisfaction in the type of broad general education he secured in college.

While at the University of Indiana he came in contact with Professor Kirkwood. Just what influence Kirkwood may have exerted over Leavenworth is not known, but in the autumn after graduation he became a pupil of Ormond Stone in Cincinnati Observatory. During his year of study and observing at Cincinnati he had as fellow students several young men training for astronomy, including Herbert A. Howe, Albert S. Flint, and Herbert C. Wilson.

About this time the University of Virginia received a generous gift from Leander J. McCormick of Chicago to build and equip a large observatory. Professor Stone was chosen to come to Charlottesville to become the director of the new observatory with its 26-inch Clark telescope. At the invitation of Professor Stone, Leavenworth became assistant in the McCormick Observatory, which position he held from 1881 to 1887. During these years he did some graduate work at the University of Virginia.

On October 11, 1883, he was married to Jennie Campbell of Louisville, Kentucky. Their children are Mrs. Burt L. Newkirk of Schenectady, New York; Frank M. Leavenworth of Bradford, Pennsylvania; and Dr. Richard O. Leavenworth of St. Paul, Minnesota. Mrs. Leavenworth died August 20, 1920.

In 1887 Leavenworth became director of the Observatory at Haverford College which had acquired a 10-inch telescope from Alvan Clark in 1883. While at Haverford he obtained the degree of M. A. from the University of Indiana in 1888.

After five years at Haverford, Leavenworth moved to Minneapolis to become Professor of Astronomy at the University of Minnesota, and Director of the new observatory about to be erected and to be equipped with a 10½-inch refractor, built by Brashear and Warner and Swasey. In this position he served almost continuously for thirty-five years until 1927, when reluctantly, because of the retirement rules of the University, he became Professor Emeritus.

During the World War when the government needed a large number of trained navigators, Professor Leavenworth was given a leave of absence from the University for the second semester in 1918 to teach navigation in a nautical school conducted at Duluth by the Shipping Board.

Leavenworth's scientific work consisted mostly of making observations in that branch of astronomy known as Astronomy of Position. He made many measures of comet positions. At the McCormick Observatory he discovered 250 new nebulae, and noted their positions. At Cincinnati he began the observation of double stars, which he carried on almost continuously throughout the remainder of his life. It is these double star observations that constitute his main contribution to astronomical science. They were made not only at Cincinnati, McCormick, Haverford, and Minnesota Observatories, but also at the Goodsell Observatory where he spent the summer of 1893, and at the Yerkes Observatory during the summers of 1914, 1916, and 1919. His double star observations were published in the *Publications of the McCormick Observatory,* in the *Haverford College Studies,* and in the *Astronomical Journal.* There remain several hundred measures made at the Observatory of the University of Minnesota that are as yet unpublished. Leavenworth was not as swift an observer as some, but the painstaking care and good judgment used made his observations possess a high degree of precision and dependability.

While at Haverford, Leavenworth made extended observations on four double stars to determine relative parallax. Perhaps no one ever applied this method of William Herschel more successfully. In later years when this method had been entirely superseded by the photographic method, he took a pardonable pride in pointing out to his colleague how well his results agreed with those obtained photographically.

The 10½-inch objective furnished by Brashear for the telescope at the University of Minnesota can be changed from a visual to a photographic telescope in a few minutes by simply replacing the front lens of the system by a third lens. The scale of the photographs obtained is the same as the scale of the astrographic catalogue plates. Leavenworth used this photographic telescope in the Eros campaign in 1901 to determine the solar parallax.

In 1918 Leavenworth became quite interested in making naked eye observations of the magnitude of Nova Aquilae No. 3. The American Association of Variable Star Observers was then coming to the front. It was quite natural to transfer his acquired enthusiasm for the Nova to the irregular variables. For nearly ten years he divided his observing time between double stars and variables.

In reviewing the career of Professor Leavenworth we must not forget that he was a professor. The one thing that was expected of every professor was to teach students in classes and in laboratory. If the professor could do research in addition to teaching, that was fine. It

is only in the more recent history of the University that the importance and value of research has been recognized. Thus hundreds of students came under his influence in the classroom. As a teacher of astronomy he never was a taskmaster, but rather an interpreter of nature, inspiring others to be interested in the science which meant so much to him. Several of his students continued their training at larger observatories and became professional astronomers. Not until the near approach of his retirement from teaching did he realize how much the teaching meant to him. His mind was poorly prepared for the transition.

In his relations with his colleagues and friends he was very unassuming, and disliked to be in the lime light. It was a noticeable nerve strain for him to give a public lecture, or to speak on a question in faculty meeting. This self-consciousness disappeared in the more intimate relations with his students in the classroom and office, where his patience, faith in human nature, and pleasant humor made every one love him.

Professor Leavenworth was a member of Phi Beta Kappa and Sigma Xi fraternities. He was a Fellow of the Royal Astronomical Society, and a member of the American Astronomical Society. Caring much for the aesthetic things of life he enjoyed good literature, drama, and music. Indeed, this led to his undoing, for in June, 1927, he attended a musical pageant in the University Stadium on a cool evening, where he contracted an infection that put him in the hospital, and from which he never sufficiently recovered to resume his astronomical work. He died in St. Joseph's hospital, St. Paul, on November 12, 1928.

An incident related by Professor George P. Conger at the funeral service for Professor Leavenworth, is a fitting interpretation of his character. "Last evening on my way home from the University I stopped at the corner news stand to buy a paper. The news boy handed me my paper and as I started away with it he followed me, pointed to something on the printed page, and said:

" 'Say—gee—it's too bad about that there—astronomer—over at the University. I recognized his picture, right away. He's bought lots of papers from me, and he was fine. He used to have two children with him. I was over there and looked through that thing—telescope—a couple o' times when I was smaller'—and then slowly and with a trace of huskiness in his voice—'Gee—he—was a—good—man.' "

A GRAPHIC INTERPRETATION OF THE OCCULTATION REDUCTION FORMULAE.

By LELAND S. BARNES.

For the past three years Professor E. W. Brown has been conducting an international campaign to obtain observations of star occultations by the moon in order that tables of its motion may be made more accurate. This is being effected by observing the error in the moon's predicted place at every available occultation, the error being obtained in the following manner.

Whenever an occultation occurs the observer[1] notes, and records, the exact time of the star's disappearance. For this time, the positions of the moon and star are interpolated from the tables in the ephemeris and the predicted angular distance between the star and moon's center obtained. This angle would exactly equal the semi-diameter of the moon if the lunar tables were correct. However, since slight errors[2] still exist in the tables, the angle will usually be slightly different from the moon's semi-diameter and this difference gives the error in the moon's position.

The calculation involved in reducing observations is made easier in practice by using a method, the basic principle of which was introduced by Bessel, the founder of modern eclipse theory.

Briefly, the method is this. Suppose one were transported to the star being occulted and viewed the earth from this position. Suppose also, a plane passed through the center of the earth, perpendicular to the spectator's line of vision. From the star the moon would be seen passing in front of the earth and its shadow would appear projected directly behind it on the plane. Also the observer on the earth would appear projected against this plane, and would be seen at the shadow's edge at the actual instant of occultation. At any other time the shadow's edge would appear as far from the observer as the moon's limb appeared from the star when seen from the earth.

The problem of the computer then becomes one of finding mathematically the predicted positions of the observer and center of the moon's shadow on the plane as seen from the star, for the instant the occultation actually occurred. The distance between these two points

[1] Throughout this paper the word "observer" refers to the observer of the occultation, his position on the earth, or his projection on the fundamental plane. Which of these meanings is to be taken will be clear from the context.

[2] These errors may not actually be due to the moon's motion but rather to our clocks. Thus, instead of the moon being slow our clocks may be fast or vice-versa. As the clocks are regulated by the rotation of the earth, Professor Brown is coming to the conclusion that it is the rotation of the earth and not the motion of the moon which is irregular.
See "Is the Earth's Diameter Changing?", *Scientific American*, July, 1926.

on the plane is next found, and finally the difference between this distance and the radius of the moon's shadow is determined.

The above method of reduction, though more simple than at first might be expected, takes a good deal of computation. Besides, it has to be applied to each observation individually, and since the number of observations being reported is steadily increasing, the work involved is becoming very great.

As practiced computers have had too little available time to handle this material by themselves, it became necessary to call for help from outsiders who had had little or no experience with such matters. Obviously, this presented the necessity of putting the calculations in a form that could easily be understood, and Professor Brown therefore devised a blank form for the entire reduction. This form has sixty-eight steps, and can be filled in without much difficulty by anyone who has a knowledge of elementary astronomy and trigonometry.

REDUCTION OF OCCULTATION, FORMULAE OF INNES. Date and Obs.Time.....Weather.....

Star.....Limb.....Place.....Observer.....Computer.....

		Logs	Nos			Logs	Nos
1	Standard Time			37	$(\delta'-\delta)$ (26)		
2	±λ E+-, W-+			38	Constant	4.3855	
3	Sum = T, (G.C.T.)			39	x^2 (33)		
4	±λ E+-, W--			40	sin δ' (17)		
5	Sum = L.C.T.			41	Sum		
6	RA Mean Sun +12^h, at 0^h			42	cos δ (32)		
7	Red. for h,m,s of (3)			43	Diff (41,42)		
8	Sum (5,6,7) = θ = L.S.T.			44	Diff (37,43) = y		
9	Δα						
10	Δδ			45	Sum (15,19) = Y"		
11	α = Moon's RA at T			46	cos δ' (17)		
12	δ = " dec. "			47	Sum		
13	π = " par. "			48	X" (34)		
14	Constant		-0.16	49	sin δ' (17)		
15	Sum = π"			50	cos $(\theta-\alpha')$ (20)		
				51	Sum		
16	α' = Star's App. Place			52	Diff (47,51) = η		
17	δ' = " " "						
18	X = ρ cos φ' (5 dec.)			53	Sum (33,36) = (x+ζ)		
19	Y = ρ sin φ' "			54	Sum (44,52) = (y+η)		
20	Diff (8,16) = $(\theta-\alpha')$ arc			55	Diff = tan χ		
21	$(\alpha'-\alpha)^s$			56	Constant	1.17609	
22	Corr. (-.212 xΔα)			57	Δα (9)		
23	Sum = $(\alpha'-\alpha)$			58	cos δ (32)		
				59	Sum		
24	$(\delta'-\delta)$"			60	Δδ (10)		
25	Corr. (-.212 xΔδ)			61	Diff (59,60) = tan ρ		
26	Sum = $(\delta'-\delta)$						
				62	Diff (55,61) (χ-ρ)		
27	π" (15)						
28	Constant	9.43536		63	$(x+\zeta)^2$ (53)		
29	Sum = σ			64	$(y+\eta)^2$ (54)		
				65	Sum = $(\sigma')^2$		
30	Constant	1.17609		66	σ		
31	$(\alpha'-\alpha)^s$ (23)			67	σ (29)		
32	cos δ (12)			68	Diff = $(\sigma'-\sigma)$		
33	Sum = x						
34	Sum (15,18) = Y"						
35	sin $(\theta-\alpha')$ (20)						
36	Sum = ζ						

FORM FOR COMPUTATION.

However, this very simplicity presents one drawback because it enables the computer to fill in the blank and sooner or later arrive at the correct result without having much idea of what he is really doing.

When work is done in this manner a mistake may be made in the early part of the computation which will not be uncovered until near the end, while if the procedure is visualized step by step, large errors will become apparent by their unreasonableness, corrected when made, and much recomputation avoided.

It was with this thought in mind that the present paper was written, in which the diagrams illustrate each step of the work. These diagrams have been made expressly for the Brown computing blank and the various steps listed on the drawings refer to the same steps on the blank. In fact, with a few minor exceptions, such as giving the value of the constants, the steps are exactly duplicated. However, use of the figures is not so limited but that they will be helpful in studying the general theory of eclipses and occultations.

The explanation of the figures will perhaps be clearer if a few general remarks are made at this point.

It should be borne in mind that occultations are merely miniature solar eclipses, and that all formulae which apply to eclipses apply in a simplified form to occultations.

This simplification is brought about by the following facts. Since the star is considered to be at an infinite distance, its parallax and motion are negligible, the shadow of the moon can be taken as a cylinder instead of a cone, and all points on the surface of the earth project onto the fundamental plane along parallel lines.

In the corner of each figure will be found all the steps, and no others, which the drawing illustrates. The words "sum" or "diff." refer to the sum or difference of logarithms in steps 29, 33, 34, 36, 41, 43, 45, 47, 51, 55, 59, and 61. In all other steps they refer to the sum or difference of numbers or angles.

Throughout this paper α and δ refer to the right ascension and declination respectively of the moon, while α' and δ' denote the right ascension and declination of the star.

Steps 1-12, 16, and 17 are not included in the paper as they are only for the purpose of interpolating the position of the moon, etc., and are not well adapted to graphic interpretation.

A detailed discussion of the figures now follows.

Figure 1. Let the large circle yRy'Q represent the earth and O the center of the earth. If a plane be passed through this center and also be so placed that it is perpendicular to a line joining the centers of the star and moon, this plane will be one of great importance, not only in the study of occultations, but in the entire theory of eclipses. It is given the name of "Fundamental Plane."

In the drawing the fundamental plane intersects the earth's surface in the line yxy'd and the shaded area represents that part of the plane which lies wholly inside the earth. The plane of the earth's equator will intersect the fundamental plane in the line dOx. If now y'Oy be

taken, passing through O and perpendicular to dOx, there results a system of coördinate axes with the origin at the center of the earth. For the present the positive direction of the axes will be taken as O towards x for the x-axis and O toward y for the y-axis.

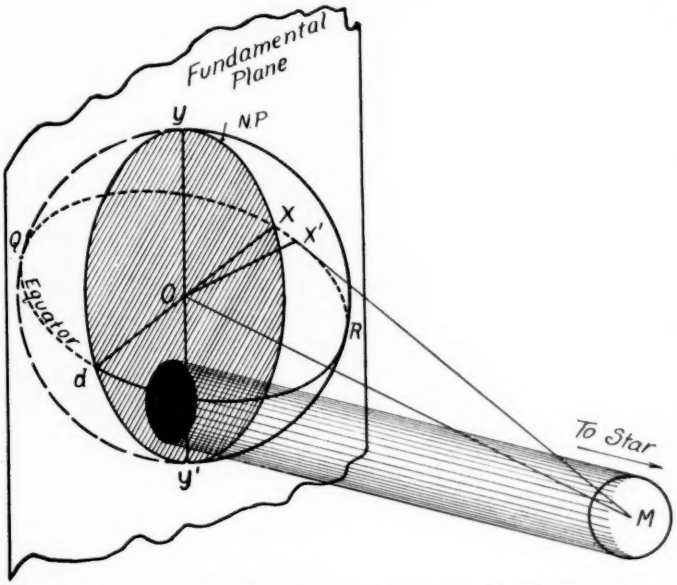

FIG. 1. ILLUSTRATION OF FUNDAMENTAL PLANE AND MOON'S PARALLAX.

Let M represent the center of the moon, and draw MO. Draw Mx' tangent to the earth's surface on the equator at the point x'. Then angle Ox'M is a right angle and the angle x'MO is, by definition, the equatorial horizontal parallax of the moon. The latter is the angle which is found by step 13 of the computing sheet.

OM the distance of the moon is taken as unity. Since the moon's shadow is a cylinder whose elements are perpendicular to the fundamental plane, the radius of the shadow on the fundamental plane will exactly equal the radius of the moon, which is 0.2725 times the radius of the earth.

Figure 2. This figure represents the way the various bodies would appear if seen from the star at the instant of occultation. The large circle represents the intersection of the earth by the fundamental plane, which is taken as the plane of the paper. The small circle represents the moon's shadow. Of course, at the star the moon would be seen superposed over the shadow, but this fact will be neglected in the following discussion as it is only the position of the shadow which is of interest.

The observer, located on the surface of the earth, will be projected on the fundamental plane at the edge of the shadow. The coördinates of this point are denoted by ζ and η and the center of the moon's shadow, M, has the coördinates x and y.

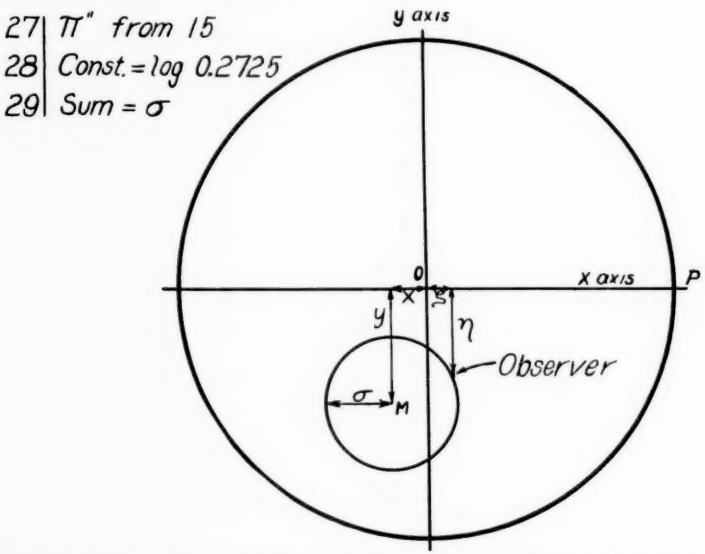

FIG. 2. TRUE POSITIONS OF OBSERVER AND SHADOW AT INSTANT OF OCCULTATION.

Since the earth's radius, which is the line OP, represents the angle π'' (see remark at end of paper under step 14), the radius of the moon's shadow, σ, represents an angle proportionately smaller, or $0.2725\,\pi''$. Thus in steps 27-29 this angle is being found or, in other words, the length σ is being expressed in arc.

Figure 3. At the actual instant of occultation the position of the observer is exactly at the edge of the shadow or at a distance σ from its center. However, if for the observed time of occultation the tabulated places of the moon are taken from the ephemeris and the position of the center of the shadow on the fundamental plane computed, it will usually be found at a distance slightly less or greater than σ (shown greatly exaggerated on this figure) and this distance is denoted by σ'. The difference between these two quantities, $(\sigma' - \sigma)$, gives the computed distance of the observer from the edge of the shadow at the observed instant of occultation and is positive if the observer is outside the shadow and negative if inside. This line $(\sigma' - \sigma)$, expressed in sec. of arc, is the angle the line would subtend if viewed from the moon, and equals the angular distance between the star and moon's limb as seen from the earth. Knowing this quantity, the error of the lunar positions in the

ephemeris can be obtained. (See also end of explanation for Figure 9).

Denoting the position of the observer by Q it will be noted that σ' is the hypothenuse of the right-triangle MLQ. The sides of this triangle ML and LQ equal $(x + \zeta)$ and $(y + \eta)$ respectively. In order to make this clear it is necessary to state at this point that, for the reason of convenience in using the final results, the positive direction of the axes has been reversed for the coördinates x and y. (This reversal is used only

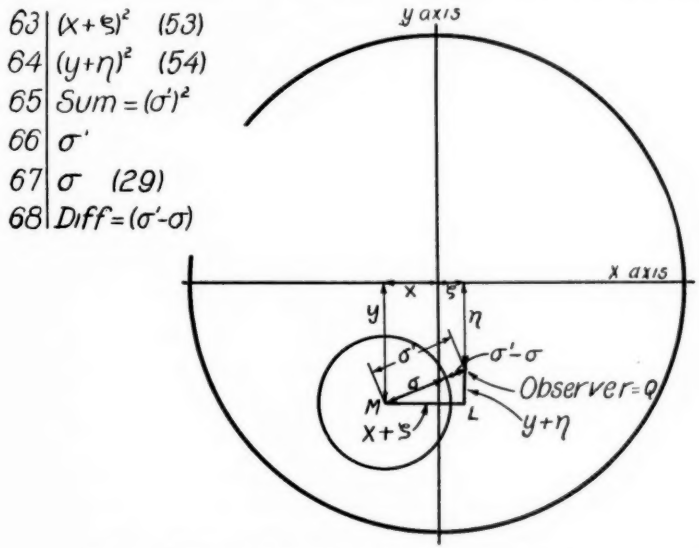

FIG. 3. COMPUTED POSITIONS OF OBSERVER AND SHADOW AT INSTANT OF OCCULTATION.

for the type of reduction here discussed. In general eclipse theory, the positive directions of the axes are identical with those first mentioned and are the same for the coördinates of both observer and moon.) Thus, in the figure, ζ, x, and y are positive while η is negative. Since in any right triangle the square on the hypothenuse equals the sum of the squares on the other two sides, there results from the triangle MLQ

$$\sigma' = \sqrt{(x+\zeta)^2 + (y+\eta)^2}$$

Figure 4. The next five figures take up in order the computation of the coördinates x, y, ζ, and η.

In this figure the fundamental plane instead of being the plane of the paper is taken perpendicular to it and intersecting it in the line CC'. The y-axis will come from the point O and point directly toward the reader who is situated north of the earth. Assume in this case that the earth's axis coincides with the y-axis. The axis might be inclined with-

out affecting the validity of the arguments to be employed but this would make the explanation more difficult to understand. The star is in the plane of the paper at a distance from O considered infinite.

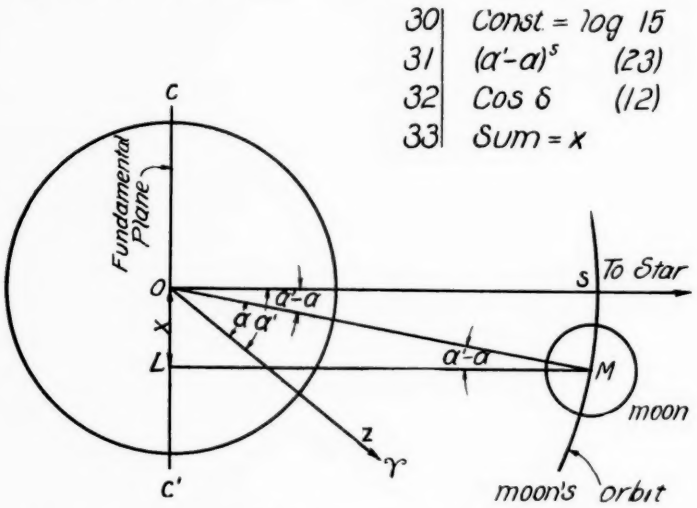

FIG. 4. THE COÖRDINATE x AS A FUNCTION OF $(a' - a)$ FOR GIVEN δ.

From M, the center of the moon, draw a line to the earth's axis and perpendicular to it. Denote the point of intersection by O. From O draw two additional lines, OZ and OS, perpendicular to the earth's axis at O, so that OZ will lie in the plane of the hour circle through the vernal equinox and OS will lie in the plane of the hour circle through the star. Angle ZOM then becomes the right ascension, a, of the moon, angle ZOS the right ascension, a', of the star, and angle MOS = angle OML is $(a' - a)$.

If the moon is on the equator and hence has its declination zero the angle $(a' - a)$ will subtend on the fundamental plane a linear distance, which has the same ratio to the earth's radius as the angle $(a' - a)$ to the angle π''. If the declination of the moon is not zero it becomes necessary to multiply $(a' - a)$ by the cosine of the declination for reasons explained under Figure 5.

Before leaving Figure 4 a brief mention of the constant, step 30, should be made. This constant is the logarithm of 15 and changes the angle $(a' - a)$ from seconds of time to seconds of arc since a second of time is fifteen times as large as a second of arc. This change is necessitated since seconds of arc are used throughout.

Figure 5. Let the circle on this figure represent a sphere with center at O and radius equal to the moon's distance from the earth. The point

P is the point where the axis of the earth extended through the north pole pierces the sphere. The great circle marked "Equator" is the intersection of the plane of the earth's equator and the sphere.

Suppose now that the moon moves along the equator from M_1 to M_2. This arc will subtend the angle M_1OM_2. If instead of moving along the equator the moon had moved along a small circle parallel to the plane of the equator, over the arc m_1m_2, the angle $m_1O'm_2$ subtended at O' would be the same as M_1OM_2 although the two arcs, as well as their projections on the fundamental plane, would, in general, be different in length.

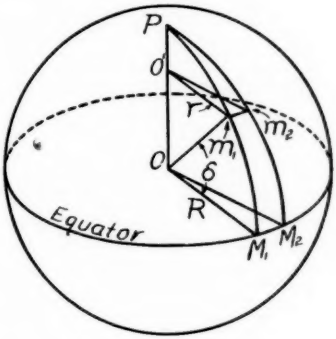

FIG. 5. CHANGE OF x WITH DECLINATION.

Since the central angles are equal, the arcs are proportional to the circumferences of their respective circles, which in turn are proportional to their radii. From the figure it is evident that $r = R \cos \delta$, so that arc $m_1m_2 =$ arc $M_1M_2 \cos \delta$. If the angular measure of the arcs is small the arcs can be considered as straight lines and their projections taken equal to their length.

Similarly, since the angle $(a' - a)$ is very small, the arcs at the moon's distance subtended by this angle can be taken as straight lines with their projections on the fundamental plane equal to their length.

Figure 6. In the figure yxy'x' represents the fundamental plane and x'SS'Lx is a great circle perpendicular to this plane. The line OS' which points to the star, is therefore perpendicular to the fundamental plane. P is the north celestial pole and the hour circle PM'S' has the same right ascension as the star. M is the center of the moon and PMS is an hour circle passing through it. The coördinate y of the center of the moon's shadow on the fundamental plane is the line CB, where B is M projected by a line parallel to S'O.

Now $CB = OR = OM \cos F = \cos F$, since OM, the distance of the moon, is taken as unity. Since the angle F is equal to the arc F' it is only necessary to solve the spherical triangle yPM for F' in order to get

37	$(\delta'-\delta)$	(26)
38	Const = $\log(\frac{\sin 1''}{2})$	
39	x^2	(33)
40	Sin δ'	(17)
41	Sum	
42	Cos δ	(32)
43	Diff (41, 42)	
44	Diff (37, 43) = y	

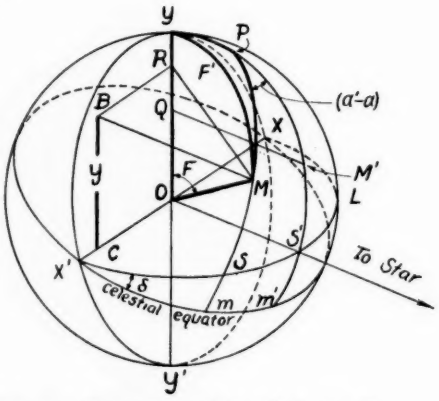

FIG. 6. THE COÖRDINATE y AS A FUNCTION OF $(\alpha'-\alpha)$, δ, AND δ'.
(The δ in this figure should be δ'.)

the coördinate y. In this triangle $yP = \delta'$, $PM = (90° - \delta)$ and the angle $yPM = [180° - (\alpha' - \alpha)]$. Now from spherical trigonometry,

$$\cos F' = \cos\delta' \cos(90° - \delta) + \sin\delta' \sin(90° - \delta) \cos[180° - (\alpha' - \alpha)] \quad (1)$$

$$\cos F' = \pm \cos\delta' \sin\delta \mp \sin\delta' \cos\delta \cos(\alpha' - \alpha) \quad (2)$$

In (2) the upper signs are obtained by a direct transformation of (1), and the lower signs are obtained by multiplying the left hand member of (2) by —1 to take care of the reversal of the positive direction of the axes for the coördinates x and y. The lower signs are taken in all further work.

By making use of the relations

$$\sin^2\theta + \cos^2\theta = 1$$

and

$$\cos\theta = \cos^2\frac{\theta}{2} - \sin^2\frac{\theta}{2},$$

equation (2) can be written as,

$$y = \cos F' = \sin\delta' \cos\delta \left(\cos^2\frac{\alpha'-\alpha}{2} - \sin^2\frac{\alpha'-\alpha}{2}\right)$$

$$- \cos\delta' \sin\delta \left(\cos^2\frac{\alpha'-\alpha}{2} + \sin^2\frac{\alpha'-\alpha}{2}\right) \quad (3)$$

$$= \sin(\delta'-\delta) \cos^2\frac{\alpha'-\alpha}{2} - \sin^2\frac{\alpha'-\alpha}{2}[\sin(\delta'+\delta)] \quad (4)$$

$$= \sin(\delta'-\delta) - \sin^2\frac{\alpha'-\alpha}{2}[\sin(\delta'-\delta) + \sin(\delta'+\delta)] \quad (5)$$

$$= \sin(\delta' - \delta) - \sin^2 \frac{\alpha' - \alpha}{2} (2 \sin \delta' \cos \delta) \tag{6}$$

Making use of the fact that the sine of an angle closely approximates the angle in seconds of arc multiplied by sin 1″ when the angle is small, and then dividing by sin 1″ to get y in ″, equation (6) becomes,

$$y'' = (\delta' - \delta)'' - [(\alpha' - \alpha)'']^2 \frac{\sin \delta' \cos \delta \sin 1''}{2} \tag{7}$$

and the second member of equation (7) becomes, on substituting x for $(\alpha' - \alpha) \cos \delta$,

$$y'' = (\delta' - \delta)'' - \frac{x^2 \sin \delta'}{\cos \delta} \cdot \frac{\sin 1''}{2} \tag{8}$$

In this equation

$$\frac{\sin 1''}{2}$$

is constant and it is the logarithm of this quantity which appears as step 38 on the computing sheet.

It seems advisable at this point to mention that if the moon and star have the same right ascension at the instant of occultation (a condition which can be fulfilled in grazing occultations only) y will equal $(\delta' - \delta)$ exactly. This can be seen from the diagram where y would equal the projection of the arc $[M'S' = (\delta' - \delta)]$ which is OQ. The same thing can be shown from equation (8) by substituting $x = 0$, since $x = 0$ when $\alpha = \alpha'$.

Figure 7. The fundamental plane is here again taken as the plane of the paper. N. P. is the north pole of the earth and is tipped slightly towards the star since the figure is drawn for a star of north declination. (N. P.)EF is a meridian of the earth on which the observer F is located. From F a line FR is drawn perpendicular to the earth's axis, meeting it in R. If it is then produced in the direction RF it will meet the celestial sphere in the observer's meridian, the right ascension of which is θ, the observer's sidereal time at the instant.

From R the following lines are drawn perpendicular to the earth's axis: RL, which lies in the plane of the hour circle through the vernal equinox, RD, which lies in the plane of the hour circle through the star, and RQ, parallel to the axis of x. The angle LRF will then equal θ, angle LRD equal α', and angle DRF the difference between these two or $(\theta - \alpha')$.

From O, the center of the earth, draw $OF = \rho'$, the radius of the earth at F. Draw also OE. The angle EOF is then ϕ', the geocentric latitude of the observer, and equals angle OFR since RF is parallel to OE. From F, FQ is drawn parallel to DR and pierces the fundamental plane in Q′ as does FR in Q″.

The coördinate ζ is now the distance of Q′ from the y-axis and this

equals RQ. Since $RQ = RF \sin(\theta - \alpha')$ and $RF = \rho' \cos\phi'$, ζ as a fraction of the earth's equatorial radius becomes $\rho' \cos\phi' \sin(\theta - \alpha')$. If to the logarithm of this quantity the logarithm obtained in step 15 is added, ζ is expressed in seconds of arc.

34	Sum 15, 18 = X″
35	Sin (θ-α′) (20)
36	Sum = ζ

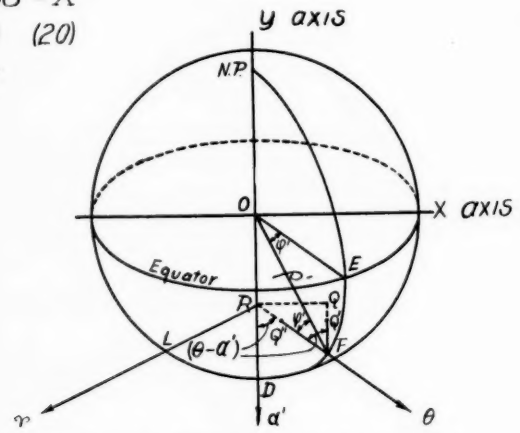

FIG. 7. THE COÖRDINATE ζ AS A FUNCTION OF $(\theta - \alpha')$, ρ', AND ϕ'.

In order to avoid repetition, it will be well to state that whenever this logarithm is added to any quantity it is for the purpose here mentioned.

Figure 8. For this figure the fundamental plane is again taken perpendicular to the plane of the paper as in Figure 4. The positive direction of the x-axis is from O directly away from the reader.

The coördinate η is made up of two parts, OR′ and R′Q′. Consider first the case where the star at the instant of occultation is on the meridian of the observer F. Then $(\theta - \alpha')$ is zero and its cosine is unity so that step 50 can be omitted. From the figure the following relations can be obtained: $OR = \rho' \sin\phi'$, $RF = \rho' \cos\phi'$, $OR' = OR \cos\delta'$, and $R'Q' = RQ = RF \sin\delta'$. By combining these quantities there results, $OR' = \rho' \sin\phi' \cos\delta'$, and $R'Q' = \rho' \cos\phi' \sin\delta'$, and η equals the algebraic difference of these two quantities. Thus, in the figure OR′ is negative, due to the sine of the negative angle ϕ', which is negative as it represents south latitude, and R′Q′ is positive so that the difference is negative, implying that Q′ is south of the x-axis.

Now take the case where $(\theta - \alpha')$ is not zero. In this instance the line RF will rotate out of the plane of the paper and will be either above or below it but at the same time will remain perpendicular to the earth's axis at R. The point F, as seen by the reader, will then appear to move along RF towards R and the projection, Q, of F will appear to move

along QR towards R the same proportionate amount that F moves on FR.

45	Sum (15, 19) = Y″
46	Cos δ′
47	Sum
48	X″ (34)
49	Sin δ′ (17)
50	Cos(θ-α′) (20)
51	Sum
52	Diff (47, 51) = η

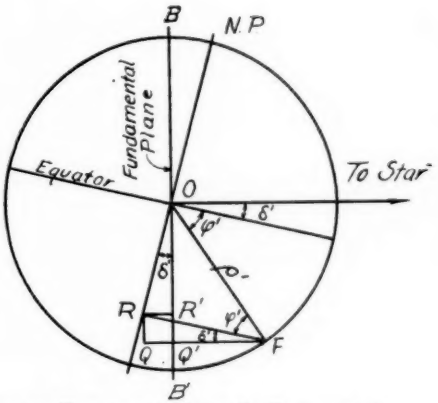

FIG. 8. THE COÖRDINATE η AS A FUNCTION OF $(\theta - \alpha')$, δ', ρ', AND ϕ'.

For example, if $\cos(\theta - \alpha') = \cos \pm 60° = 1/2$, then F would move half way to R and its projection Q would also move half way towards R.

Figure 9. This figure is seen from the same position as Figures 2 and 3 and the letters refer to the same quantities. Since the y-axis runs north and south, the angle χ gives the angle of occultation measured from the north point of the moon through the east. Now angle χ equals angle MQL, and the tangent of this angle and hence tangent χ is $(x + \zeta)/(y + \eta)$. The usual convention of sign is followed in order to determine the quadrant in which the angle lies.

The angle ρ is obtained in a manner similar to χ. In the triangle, which is placed for clearness in the upper right hand corner of the figure, the two sides give the distance (on a scale different from the rest of the plate) the moon would move parallel to the coördinate axes in one minute of time if it continued to move at the same rate it was moving at the instant of occultation. $\Delta\alpha$ and $\Delta\delta$ are the rates of motion in right ascension and declination at the instant considered, and the hypothenuse of the triangle represents the resultant direction of these two motions.

$\Delta\alpha$ cannot be taken by itself as a side of the triangle as it is expressed in seconds of time. It must first be multiplied by 15 to reduce it to seconds of arc and then multiplied by the cosine of the moon's declination for the reason mentioned under Figure 5. $\Delta\delta$ can be taken as a side of the triangle directly since it is always measured along the arc of a great circle and is already expressed in arc.

As was pointed out under Figure 3, the distance $(\sigma' - \sigma)$ gives the computed angular distance of the star from the moon's limb at the time of occultation. However, this is not the error in orbital position unless χ equals ρ. When, as is usually the case, χ differs from ρ, the error in orbital position is

$$\frac{\sigma' - \sigma}{\cos(\chi - \rho)},$$

for, since the projection of the moon's motion on the celestial sphere is not directly towards the star, the moon must move a greater angular distance than $(\sigma' - \sigma)$ in order to bring its limb to the star.

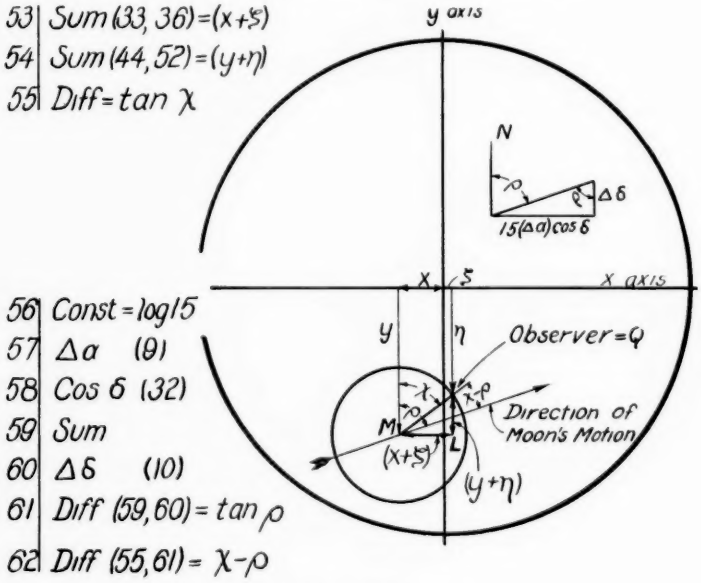

FIG. 9. THE ANGLES χ AND ρ.

It was thought advisable at this point to discuss certain steps separately from their related groups in order that the reader would not become confused with minor details while trying to see the whole. Steps 14, 18, 19, 22, and 25 will be discussed accordingly.

Step 14. This correction is the difference between the angle and the sine of the angle, expressed in arc for the average lunar parallax. Since all the quantities in the computation are expressed in terms of the angle rather than the sine of the angle, it becomes necessary to apply this correction to the parallax, which is the only angle large enough to warrant it.

Steps 18, 19. ρ' is the radius of the earth at the observing station and is expressed in terms of the equatorial radius. ϕ' is the geocentric latitude, or the angle at the center of the earth between ρ' and an equatorial radius to the same meridian. Geocentric latitude differs slightly from geographic latitude as the latter is measured by the plumb line which does not usually point to the center of the earth. Step 18 is the product of ρ' and the cosine of the geocentric latitude, while in Step 19 ρ' is multiplied by the sine. These quantities can be computed from formulae to be found in *Chauvenet's Astronomy* or in the ephemerides of various governments.

Steps 22, 25. These corrections are applied to care for errors which are known to exist in the moon's position. They could be removed without affecting in the least, the correctness of the formulae; but if this were done it would make the final value of $(\sigma' - \sigma)$ larger and more inconvenient to handle.

Department of Mathematics and Astronomy,
Lehigh University, Bethlehem, Pennsylvania.

FIREBALL OF JUNE 22, 1927.

By CHARLES P. OLIVIER.

The following observations were received from the Hydrographic Office, U.S.N., during 1927 but due to pressure of other work the writer finished the solutions only recently.

(1) "Second Officer W. Bentley of the American Steamer *W. H. Tilford*, Capt. E. C. Kelson, reports that on June 22, 1927, at $7^h\,46^m$ G.M.T., in latitude 27° 14′ N, longitude 89° 27′ W, a large meteor of bluish-white color was observed bearing about 300° (true), at an altitude of about 49°. The body disappeared, bearing 350° (true), 25° above the horizon, after being visible about 3 seconds."

(2) "Second Officer E. C. Olsen of the American Steamer *Royal Arrow*, Capt. A. A. Brock, reports that on June 22, 1927, at $7^h\,46^m$ G.M.T., in lat. 27° 06′ N, long. 88° 49′ W, was observed an exceptionally brilliant meteor lighting up the entire western sky for about 5 seconds. The body appeared close to the constellation of Corona Borealis at an altitude of about 30° and disappeared near Ursa Major, about 12° above the horizon. The meteor was of a light blue color, leaving a very bright blue-yellow trail which soon disappeared. The weather was clear."

As the ships were relatively close together, and we could hardly expect their positions to be given closer than $\pm 1'$ in either latitude or longitude, the portion of the earth's surface in question may be considered as a plane. Again, as one ship gives four coördinates for the meteor,

the other only two altitudes, the solution for the end points is unique, and we have no check whatever. By a simple geometrical construction, the heights have been solved as follows. The time of visibility is taken as $\frac{1}{2}(3+5)=4.0$ seconds. Both observers agree upon the color as bright blue. The train was not a very persistent one. The numerical results follow:

Height at beginning:	71.0 km
Height at end:	18.5
Length of path:	50.72
Apparent velocity:	17.63 km/sec.
Apparent radiant point:	azimuth 80°.5, altitude 48°.0
Correct radiant point:	azimuth 80°.5, altitude 42°.4 R.A. 249° 04′, Decl. 11° 49′ Long. 245° 12′, Lat. 33° 29′
Local sidereal time:	$19^h\ 48^m\ 35^s$
Meteor would have struck ocean:	Lat. 27° 38′.4 N, Long. 89° 06′ W
Relative velocity corrected for zenith attraction:	13.64 km/sec.

ELEMENTS.

1927 June 22.32 G.M.T. (New Style) = 1927 June 22.82 (Old Astr. Date).

	Elliptical	Parabolic
Semi-major axis	1.579	infinity
Eccentricity	0.416	1.0
Inclination	10° 00′	17° 45′
Node	89° 54′	89° 54′
Perihelion	316° 47′	315° 14′

As usual, the weakest point is the estimated time of visibility and hence the velocity. Therefore, two orbits were calculated; the first, turning out to be an ellipse of moderate eccentricity, is based upon the actual observations, *i.e.* a time of 4.0 seconds. The second orbit is based upon an assumed parabolic velocity. This latter approximately corresponds to the duration of 3 seconds as observed from the S.S. *W. H. Tilford*.

In this case, however, we are quite sure that the body moved with a direct motion in an orbit of low inclination. This adds probability to the other proof that the body was a permanent member of the solar system.

The coöperation of ships' officers is becoming of increasing value and there are several possible cases at hand from which heights and orbits may be calculated from data received in 1928. Observers, however, are urged always to send in both coördinates of each end of the path, as without these there is no check upon the probable accuracy, even when heights can be worked out as in the present case. More accurate times of visibility would also be of immense value, though these are far harder to estimate than the positions.

FLOWER OBSERVATORY, UPPER DARBY, PA., 1929 JAN. 14.

PLANET O

By WILLIAM H. PICKERING.

Through the courtesy of Captain Freeman, I have recently received from the Nautical Almanac Office at Washington, a revised list of the deviations found at the U. S. Naval Observatory, between Newcomb's Theory of Neptune and the planet's observed positions. A preliminary list furnished me by Captain Eichelberger appeared in my paper on "The Next Planet Beyond Neptune," POPULAR ASTRONOMY, 1928, **36**, 149, Table II. This early list extended only through the year 1918, when the perturbations were still small, not exceeding 1".43. The present list carries the planet through as far as the year 1925.2, when the deviations observed at Greenwich and described in that paper had become much larger. In this revised list the observations are more accordant with each other, and also more accordant with Greenwich than in the earlier one.

TABLE I.

DEVIATIONS OF NEPTUNE.

Date	H.L.	Green.	Wash.	Green.	Wash.	Mean	Dev.
1904.1	95°	+0^{s}006	—0^{s}07	+0".08	—0".98	—0".45	±0".26
05.1	97	+0.050	—0.08	+0.70	—1.12	—0.21	±0.45
06.1	99	+0.005	—0.07	+0.08	—0.98	—0.45	±0.26
07.1	101	—0.075	....	—1.05	....	—1.05	....
08.1	104	—0.062	—0.09	—0.87	—1.26	—1.06	±0.10
09.1	106	—0.052	—0.11	—0.73	—1.55	—1.14	±0.20
10.1	108	—0.072	—0.11	—1.02	—1.55	—1.28	±0.14
11.1	110	—0.018	—0.09	—1.39	—1.27	—1.33	±0.03
12.1	113	—0.073	—0.10	—1.04	—1.43	—1.24	±0.10
13.1	115	—0.068	—0.11	—0.97	—1.57	—1.27	±0.15
14.2	117	—0.082	—0.10	—1.17	—1.42	—1.30	±0.06
15.2	119	.....	—0.12	....	—1.73	—1.73	....
16.2	122	—0.148	—0.09	—2.14	—1.31	—1.72	±0.20
17.2	124	—0.138	—0.10	—2.01	—1.46	—1.74	±0.14
18.2	126	—0.156	—0.12	—2.28	—1.75	—2.02	±0.14
19.2	128	—0.182	—0.12	—2.68	—1.76	—2.22	±0.23
20.2	130	—0.160	—0.15	—2.37	—2.23	—2.30	±0.04
21.2	133	—0.185	—0.16	—2.76	—2.40	—2.58	±0.09
22.2	135	—0.123	—0.16	—1.84	—2.40	—2.12	±0.14
23.2	137	—0.171	—0.17	—2.57	—2.57	—2.57	0.00
24.2	139	—0.201	—0.17	—3.05	—2.58	—2.82	±0.17
25.2	141	.....	—0.15	....	—2.29	—2.29	....

In Table I the first four columns give the date, the heliocentric longitude of Neptune, and its deviations in right ascension from theory, according to Greenwich and Washington. The mean dates of the observations were necessarily not identical in many cases, but they never differed by more than one-tenth of a year from one another, and this would make no difference in the result. The last four columns give the deviations reduced to heliocentric longitudes, their mean, and their deviations from the mean. In Figure 1 the second and seventh columns are

plotted as abscissas at the top, and ordinates at the left. The approximate dates are given at the bottom of the figure. The little circles are plotted from the positions used by Newcomb to determine his Theory of Neptune, and are taken from Table I in the paper above mentioned. The crosses are plotted from the Table I given in this paper.

To those unfamiliar with celestial mechanics it may be mentioned that when an inner known planet K overtakes and passes an outer unknown planet U, K, which has at first been gradually gaining speed under the influence of U, will now be suddenly retarded by its backward pull. It is this sudden change of speed which enabled Leverrier and Adams to locate Neptune by computation before it was observed visually. On the

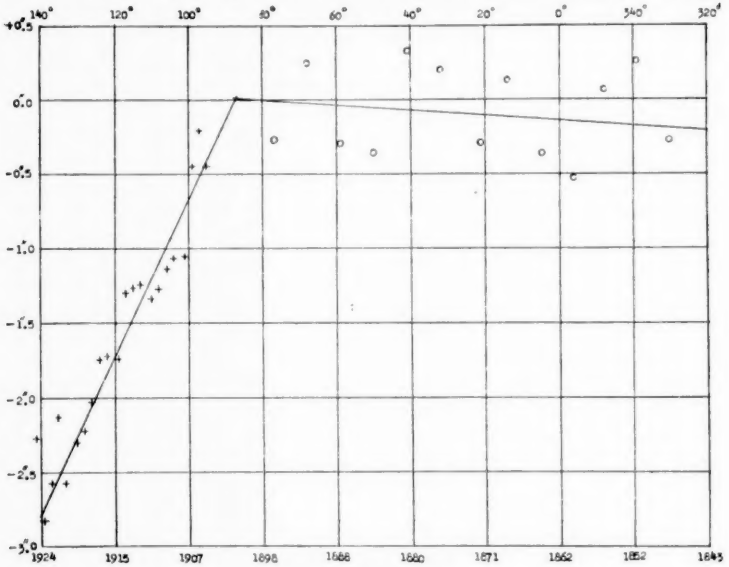

FIGURE 1.

THE ORBIT OF NEPTUNE.

other hand if the unknown planet is the inner one, and passes the outer known one K, the speed of the latter will be suddenly accelerated after the conjunction. At no other place in their orbits will any marked change of perturbation be produced. In Figure 1 the path of Neptune according to Newcomb's orbit is represented by the horizontal line 0″. We now know that owing to the pull of planet O it should really be represented by a line inclined somewhat more than the slightly inclined line in the figure, but less inclined than the steep one. It will now be seen by the figure that Neptune exhibited a change in its motion when it reached heliocentric longitude 87°. The ordinates indicate that it was

dragged back after passing that point, and it is possible that the retarding action will continue further. Since it was retarded we see by the above statement that the unknown cause, if a planet, was revolving in an orbit exterior to it. No such planet is known, and we know of no cause excepting a planet which could retard it. Since Figure 1 represents the whole of the half of Neptune's orbit that is known, it is quite evident that only one perturbation by an unknown planet has affected it during that half.

It may be pointed out here that, although this curve is undoubtedly more accurate than the one shown in Figure 4 of the above mentioned article, yet it does not differ materially from it. The Greenwich observations on which alone the later portion of the original curve was based are now fully confirmed by Washington, and really did not need it. The average deviation between the two is only 0".15, or about 1/20 of the maximum deviation. I have represented the deviations in the figure by two intersecting straight lines, but both should be slightly curved, as represented in Figure 4. The nearly horizontal one should curve downwards and intersect the other near longitude 91°, instead of 95°, the intersection formerly given. This will carry back by 0°.9 the earlier computed position of *O*.

Since it has been suggested in some newspaper articles that all the large observatories would be hunting for planet *O* when it comes to opposition this February, I wish to state here that I myself have the gravest doubts on that point. Indeed if anyone is hunting for it I shall be much gratified. The public does not generally understand how extensive an undertaking it is to search for a slow moving planet of the thirteenth magnitude. It will not show like an asteroid as a line on a single negative. Several plates must be taken on successive nights, and carefully compared in a comparator or blink microscope, or some similar device. It is no simple matter like finding a bright object like Neptune, where a glance at the map was sufficient to show that no bright star formerly existed in that place. For every star in a given area that is as bright as Neptune, there are between 100 and 200 as bright as planet *O*, and they are packed closely together in irregular groups or masses all over the plate. A single plate may contain as many as 100,000 stars. Fortunately we do not have to examine all of them—that is where the work of the computer comes in. Only a large wide-angled lens will separate the stars sufficiently from one another to make the discovery of the planet possible.

Moreover every astronomer has his own work to do, in which he is especially interested, and therefore does not feel like devoting much of his time to an investigation the result of which is not absolutely certain. It is possible also in a few cases that the astronomer may feel that he is doing all the work, and that the writer is going to get all the credit for telling him where to look. That was quite proper in the case of Neptune, which was so easily found, but certainly should not be so in the

present case. The computing is interesting, I had almost said exciting, work, while the examination of thousands of star images is most laborious and monotonous. The man who finds the planet should certainly receive as much credit as the man who tells him where to look. I certainly hope that some one will find it this year, for as I have already pointed out, the error possible in my ephemeris each year grows larger and larger, and there will be no opportunity to check up, and get further information from the planets themselves, for at least another hundred years. As I have also pointed out, graphical methods similar to the one that I have employed are the only ones that are of any use at all in a case like this, for with three unknown planets, *O*, *S*, and *P*, all three producing deviations of about the same amount, each interfering with the effect of the other two, and, with an incomplete orbit for Neptune, any analytical method, such as that adopted by Leverrier and Adams, would be hopelessly inadequate.

So far as I am aware no one has done more than give a casual glance at the region indicated for the planet, or has searched for it excepting close to the ecliptic. No exhaustive search whatever has been made. In case I am mistaken in this matter I should be very glad to learn the limits of the area examined, and the probable faintness of the stars clearly shown upon the negatives, for the benefit of other investigators. It must be recalled that the planet is believed to be a little to the south of the ecliptic, possibly as much as 5° or 6°, but not more, and that its longitude is better known than its latitude. (See "The Three Outer Planets Beyond Neptune," POPULAR ASTRONOMY, 1928, **36**, 423.)

PRIVATE OBSERVATORY, MANDEVILLE, JAMAICA, B. W. I., DECEMBER 15, 1928.

AMERICAN ASTRONOMICAL SOCIETY.

(Continued from page 89)

LOWELL OBSERVATORY

FLAGSTAFF, ARIZONA

The visual and photographic study of the planets Saturn, Jupiter, Mars, Venus, and Mercury, has been continued. The observations have been made with considerable regularity, particular emphasis being placed on large-scale photographs with the 24-inch refractor and color filters. Some 600 plates have been secured. Color filters of various transmissions and plates sensitive to different regions of the spectrum have been employed for the red, yellow, blue, and ultra-violet.

The photograph proves a very efficient means of recording the surface features of Jupiter and Saturn. The major portion of the record of these two planets has been secured with blue and yellow light in order to maintain a homogeneous record, but red and ultra-violet photographs

have been made for special information.

Venus has been observed regularly, when distant enough from the Sun to permit of violet and ultra-violet photography, for the purpose of detecting, if possible, rotational and seasonal effects as well as the further purpose of obtaining photographs of the disk to be correlated with simultaneous radiometric measures. These short-wave photographs show at times large bright and dark areas, at other times a nearly uniform disk. The variation seems chaotic but offers some explanation for the frequent and marked variations in the radiometric measures of the disk which have been observed here for some years.

Although very distant throughout the year, Mars has been observed occasionally in order to maintain the long record kept here.

Mercury has been observed at opportune times and some fairly successful photographs have been obtained in red, yellow, and violet light. These bear out the earlier conclusions reached here regarding this planet. These first attempts to photograph this difficult planet are encouraging enough to warrant further work in this direction.

The many important differences which occur in photographs of the planets with long and short wave light, and the changes on the planets themselves, cannot be summarized here. Attempts to establish a period for the recurrence of like aspects of Jupiter, such as the present and the similar one in 1920, and their possible connection with some influence in the solar system, have led to no definite result. While the period for which we possess comparable observations still appears too short to give any safe result, yet the examination of the photographic record of the planet maintained here since 1904 hints that further extensions of it would furnish valuable information on these questions and about the planet in general.

Radiometric observations have occupied much of the time of the 42-inch reflector. Measures have been in progress on Mercury, Venus, the Moon, Mars, Jupiter, and Saturn. The Sun and several stars are also being observed with various transmission screens used in checks and comparisons of the planetary measures. In these observations Mr. Lampland has been assisted by Mrs. Lampland.

It is aimed to complete as early as possible the main part of the program of planetary radiometric observations but the work of reducing and evaluating the measures is somewhat in arrears. Radiometric measures on Venus for some years past indicate that conditions over the surface undergo considerable variations. The rapid and enormous changes in the surface markings of Jupiter, as to form, color, and location on the surface, as shown both by visual and photographic observations, might lead one to expect interesting things radiometrically. The water-cell transmissions of parts of the planet exceed (autumn 1927) in many instances the water-cell transmission of the directly observed solar radiation. Selective absorption of the planet's atmosphere may largely account for the high transmissions observed but other factors

may also be involved. Another interesting result was that the measured total radiation from the south polar zone was 25 to 50 per cent higher than from the north polar zone.

The appearance of Skjellerup's comet as a great daylight object, about the middle of December, 1927, afforded an opportunity at Flagstaff to secure some important observations of this brilliant visitor. Some photographic record of it was obtained in spite of its close proximity (less than 5 degrees) to the Sun, by photographing it in red light, in midday. At the same time interesting spectrum observations were made. The comet's light, on the first day, December 16, was essentially reflected sunlight and showed only as an intensified strip over the solar spectrum of the daylit sky. No emissions, bands or lines, could be found on that date. But the next day bright sodium lines made their appearance and lasted throughout the period of observation, the continuous spectrum becoming fainter and unrecognizable against the daylit sky spectrum. While a great many spectrograms were secured, none of the typical cometary carbon bands appeared. The [D] lines, the only recognized comet emissions, became very bright. Strangely enough these two lines were of equal strength in the comet, whereas in the spark and in the Sun [D_2] is much the stronger of the two. High dispersion, doubtless the highest ever used on a comet, was employed, and the velocity of the comet relative to the Earth was very accurately determinable, amounting at its maximum to fully 90 km/sec.

A preliminary report of the radiometric observations of this comet was presented at the New Haven meeting of the American Astronomical Society. These radiometric measures are probably the first to be made of a comet. An effort was made earlier in the year to use the radiometer on the Pons-Winnecke comet but its radiation was too feeble to obtain trustworthy results. For Skjellerup's daylight comet it was possible to obtain quantitative values for transmissions with several screens. The marked and progressive changes in the character of the radiation from the comet are no doubt significant as bearing on the material composition of the nucleus and the activity of cometary matter under the stimulus of intense irradiation near the Sun. Measurements with several screens, having various transmission limits, and passing radiations of much longer wave-lengths than the water cell, show clearly the progressive increase in the amount of low-temperature, infra-red, radiation, and also indicate that selective emissions occurred. On the first day the measured water-cell transmission was 75.6%, about the same value as the transmission of direct sunlight. The spectrograph then showed only reflected sunlight, with no indications of bands or lines. On the second day the measured water-cell transmission was 40.5%, and by that time the spectrograph had recorded bright sodium lines.

The spectrographic work has followed previous lines, and here only a few items need special mention. Spectra of Uranus and Jupiter with greater extension into the infra-red, as far as to λ 8600 for Jupiter, re-

vealed absorption bands (most of them new) near: 802$\mu\mu$ very prominent, 817$\mu\mu$ narrow, 839$\mu\mu$ strong, and 857$\mu\mu$ strong.

A new spectrograph of the highest light-power existing for spectra of faint extended objects was completed and put to use. It has speed sufficient to record, under usual conditions, the chief yellow aurora line of the sky in 2 or 3 minutes; and has been especially efficient with our other spectrographs—in extending the long continued study of the spectrum of the faint general light of the sky. It was found last spring that the nitrogen bands typical of the spectra of auroral displays, while long known not to be present through the night, do flash out briefly with the first traces of dawn and similarly in the evening. The long established variation in the permanent yellow aurora line is brought out reliably by running throughout good nights a long series of short exposures. On some nights it varies greatly, on others it holds its strength steadily and again its variation even on consecutive nights may be not at all comparable, and hence the large amount of material here to be satisfied does not invite hasty general conclusions.

Mr. A. L. Bennett has secured during the year an extensive series of Moon photographs for detailed photometric study of its surface features. It is expected that this research may also coördinate in a useful way with the radiometry of the Moon and have a further application in the study of planetary radiometry.

During July, August, and part of September the Observatory staff enjoyed the privilege of a visit from Professor Henry Norris Russell of Princeton University. He delivered a series of lectures on spectroscopy then and also assisted the members of the staff with his valuable counsel in many problems, for which it is a pleasure to make acknowledgment.

Professor W. A. Cogshall, Director of the Kirkwood Observatory, spent July and August at Flagstaff where he further extended the excellent series of photographs of the Milky Way he began here the preceding summer using a rapid 5-inch Cooke Astro lens.

At the meeting of the International Astronomical Union at Leiden the Observatory was represented by Mr. and Mrs. C. O. Lampland, who were abroad from June to September.

During the second half of the year the Observatory instrument shop has been occupied with the mounting and dome for the new photographic telescope. The lens, of the Cooke Astro type, of thirteen inches aperture and sixty-three inches focus has been figured by Mr. Lundin of Alvan Clark & Sons. The first work of this instrument will be the completion of a special survey problem begun many years ago.

V. M. SLIPHER, *Director.*

OBSERVATORIES OF THE UNIVERSITY OF MICHIGAN

ANN ARBOR, MICHIGAN, AND BLOEMFONTEIN, SOUTH AFRICA

Instruction. Twenty courses in Astronomy were offered by the Observatory staff during the year. Miss Gretchen Mullison received the master's degree, and Mr. H. F. Schiefer, the doctor's degree. Miss Hawes, Mrs. McLaughlin, and Miss Seydel were actively engaged in work on their theses for the doctor's degree.

A 3-inch transit was added to the equipment of the astronomical laboratory during the year. Designs for a 15-inch pyrex reflector were completed and construction begun. The optical parts were ordered from J. W. Fecker.

Research. Observations with the two-prism spectrograph attached to the 37½-inch reflector were continued through the year. This two-prism instrument, giving twice the dispersion of the spectrograph previously employed here, has been especially useful in the analysis of structures and structure changes in complex lines of Class Be spectra. A careful study of the constants of this instrument and of the spark spectrum of Fe-Ti alloy has been made by Mr. Maxwell.

The principal observing program related to stars of Class B, with emission line spectra, north of —20° declination. Intensive observations have been continued on a number of ϕ Persei spectrum variables. A Moll self-registering spectrophotometer has been used with success in the study of spectra of γ Lyrae, β Lyrae, ϕ Persei, f^1 Cygni, and other stars. A second spectroscopic program included the intensive observation of brighter Algol stars.

Studies of velocity curves with especial attention to irregularities due to rotational velocities during partial eclipse have been continued in the cases of Algol, and other stars.

Spectral studies of ϕ Persei, β Persei, δ Cephei, HR 985, b_2 Cygni, υ Cygni, υ Sagittarii, ζ Tauri, α Lyrae, γ Lyrae, β Lyrae, ϵ Aurigae, and other objects were also carried on during the year.

The measurement and reduction of numerous spectrograms of twenty intrinsically brighter stars were continued for the study of changes in wave-length with spectral class over the spectral range of the brighter Cepheids. This is being done to aid in the interpretation of wave-length variations synchronous with the light changes of Cepheid variables.

Those engaged in the spectroscopic observations and investigations were the following: R. H. Curtiss, W. C. Rufus, D. B. McLaughlin, A. D. Maxwell, H. F. Schiefer, Hazel M. Losh, O. L. Dustheimer, Alberta M. Hawes, Laura E. McLaughlin, Frances L. Seydel, N. L. Pierce, and M. B. Stephenson.

The 12-inch refractor, with a Zöllner photometer attached, has been employed by Mr. McLaughlin in the measurement of variable stars, especially of eclipsing binaries, chosen mainly from among those of especially long period and late spectral class.

Numerous observations have been obtained of RS Ari, ϵ Aur, RZ Cnc, RT Leo, RW CrB, TT Her, WZ Oph, AK Her, AD Her, and S Equ. A beginning has been made on W Sct. RX and RY Gem and RU Eri will be added to the program during the coming winter. Other stars observed are RV Tau, TU Aur, RU CrB, W Ser, and TW Peg. The probable error of a single observation calculated from the residuals from the light curve of observations of RZ Cnc and RT Leo at maximum light is $0^{M}.037$.

Studies of the light curve of R Scuti were carried on by Mr. Curtiss in collaboration with Professor Alter and Mr. Robb.

Contributions. Mr. Curtiss and Mr. Rufus were engaged during the year in the preparation of material for the *Handbuch der Astrophysik*. Various papers of members of the staff were published in current periodicals or presented before scientific societies.

Changes in Staff. At the end of the year Mr. W. J. Williams was added to the staff as instructor when Dr. Schiefer resigned to accept a position at Des Moines University. Professor O. L. Dustheimer was a visiting member of the Summer Session staff in 1927.

The Lamont Expedition. The southern station has been officially named, "The Lamont-Hussey Observatory." It is supported entirely by Mr. R. P. Lamont. The building with ample office, library and other space was completed in February, 1928. The 56-foot dome and 27-inch Lamont Refractor were then erected and completed for the beginning of a regular observing program on May 9, 1928. Up to September 1, 1928, the total of discoveries of new double stars was 312, including pairs with separations down to $0''.16$, and many remeasures of known pairs had been made. These double star results will appear from time to time, in lots of one hundred by each observer, as parts of the Hussey Memorial Volume.

R. H. Curtiss, *Director.*

MOUNT WILSON OBSERVATORY

Carnegie Institution of Washington

Pasadena, California

The maximum of the present cycle of solar activity seems to have been reached during the first half of 1927. The remainder of the year showed a marked decrease, followed early in 1928 by an increase which did not reach the high level of the preceding year. The spectra of sun-spots have been photographed in the near infra-red to a limit much beyond that reached previously. Observations of solar disturbances and fields of force in the sun's atmosphere have been carried on regularly by Hale with the spectrohelioscope, and most valuable results have been obtained from measurements of the radial velocities of the dark and bright prominences rendered visible with this instrument.

A total of 424 groups of sun-spots was observed on 312 days during the calendar year. Polarities were determined for 405 individual groups, of which 394 proved to be regular, and only 11 irregular, in the sign of their magnetic fields.

The revision of Rowland's Table of Solar Spectrum Wave-lengths has been completed by St. John and his associates. In addition to the wave-lengths, upon the International System, of nearly 22000 lines, the table contains a great number of new and revised identifications, and a large amount of physical data relating to the temperature and pressure classification of the lines, their energy-levels and multiplet relationships. The presence of a number of elements not known previously in the sun's atmosphere has been established in the course of this work.

The extension of this table toward longer wave-lengths has been made possible by Babcock's investigation in the infra-red. He has been able to secure negatives showing the principal lines as far as λ 11900. Over 600 new lines have been measured, among them the prominent line of the Ritz-Paschen series of hydrogen at λ 10049.

A calibration of the intensities of solar lines given in Rowland's Table has been carried out by Russell, Adams, and Miss Moore. The resulting tables give a relationship between the relative numbers of atoms active in producing a line and the Rowland intensity, and may be applied to stellar spectra for which the Rowland scale has been used.

In the continuation of his investigation St. John finds that lines of medium level in the solar atmosphere show the displacement in exactly the amount predicted by the relativity theory, while those of higher level show somewhat more, and those of lower level somewhat less. A study of these lines at the sun's limb indicates that the deviations are probably to be ascribed to convection currents in the solar atmosphere.

The results of Pettit's observations of solar radiation at $\lambda 0.32\,\mu$ show a marked parallelism with the curve of sun-spot group numbers. The principal changes in light of the sun as a variable star are in the ultra-violet. Pettit has also measured the ultra-violet radiation of the sky under various conditions of clearness. The amount is found to be surprisingly large even on completely cloudy days.

Dr. Ross completed a series of photographs of Venus in light of different colors. He concludes that the rotation period is less than the orbital period, and that the diameter in ultra-violet light is about 2 per cent greater than in red light; also that the outer atmosphere is composed of a thin stratum of cirrus clouds, while the inner atmosphere is dense, and yellowish in color.

Hubble continued his survey of faint nebulae. He has completed his study of stars in the Andromeda nebula, finding the distance to be about 5 per cent greater than that of Messier 33. The 86 novae observed in the Andromeda nebula indicate a frequency of between 25 and 30 a year, and a restricted range of 3 or 4 magnitudes at maximum. The maximum frequency occurs at photographic magnitude 16.5, or

absolute magnitude —5.7 at the distance indicated by the Cepheid variables.

Hubble finds a correlation between exposure time and numbers of nebulae, corresponding approximately to uniform distribution in depth. About 170 nebulae per square degree are found on negatives exposed 2 hours with the 100-inch.

Humason has determined a radial velocity of —130 km/sec for N.G.C. 6822 from measurements of emission lines; a radial velocity of —300 km/sec, and a spectral type of F5n, for N.G.C. 205, the fainter companion of the Andromeda nebula; and a radial velocity of +1500 km/sec for the small spiral nebula, N.G.C. 4884. Merrill has photographed the nebular lines in the red, and his detection of the double character of λ 7325 confirms Bowen's identification of it.

Van Maanen finds a probable error of ±0".006 for the trigonometric parallaxes obtained at the Cassegrain focus of the 60-inch, and ±0".010 for those at the primary focus of the 100-inch. Investigating trigonometric parallaxes by different observatories, he concludes that errors which depend on right ascension are present in all the series.

The completion of the great catalogue of photographic magnitudes of the stars in the Selected Areas is a notable event. Carried on by Seares, with the assistance of Miss Joyner and Miss Richmond, and in coöperation with the Kapteyn Laboratory at Groningen, this investigation has involved the measurement of the photographic magnitudes of about 65000 stars extending to an average limiting magnitude of about 18.5. The final magnitudes show a high degree of accordance with one another and with the scale of the North Polar Sequence, and, in addition to providing numerous standards well distributed over the sky, afford abundant material for several of the problems of stellar distribution.

The 15-foot spectrograph has been used for obtaining the spectra of bright stars on a very large scale, and a new plane-grating spectrograph for the near infra-red region. Many spectrograms of faint stars of large proper motion, variable stars, and faint components of visual binaries have been obtained with the low-dispersion spectrograph.

The relative velocities of the components of the Algol variables X Trianguli and RT Sculptoris have been determined by Joy; the velocity-curves of the Cepheid variables T Monocerotis, U Vulpeculae, and TU Cassiopeiae by Sanford; and the orbits of two spectroscopic binaries, each of which is a component of a visual binary, by Sanford. Radial velocities of +170 km/sec and —390 km/sec have been found by Joy and Adams for the Cepheid variable AG Aurigae and the short-period variable TU Persei, respectively. Sanford's observations of the eclipsing binary RX Herculis have brought the mass of this star into agreement with Eddington's mass-luminosity relationship.

Strömberg finds that among the super-giant stars of types K3-K5 the dispersion in velocity is small. The average peculiar radial velocity of the ordinary giants is 20 km/sec, and the solar motion derived from

them is 25 km/sec. There is no trace of Kapteyn's two streams, but the asymmetry in velocity-distribution is very marked.

Joy has determined the velocity-curve of U Sagittae and the absolute dimensions of the system. Absolute dimensions have also been derived by Joy for RT Lacertae and RS Canum Venaticorum, both of which show spectra with double lines.

Merrill has studied the relative intensities of certain pairs of emission lines in the spectra of long-period variables, and finds a progressive change during the whole time within which the lines are present. The behavior of the bright lines, therefore, evidently does not depend solely on the apparent brightness of the photosphere.

Merrill has identified many of the prominent emission lines in the spectra of η Carinae and certain M-type variables as "forbidden" lines of the ionized iron atom. These lines have never been observed in the laboratory. Joy found, in June, 1928, many of the forbidden lines in the spectrum of the irregular variable RT Serpentis, and some remarkable changes in other spectral characteristics. The forbidden lines have also been observed in the spectra of several B-type stars with bright lines.

Further stellar spectroscopic investigations have included a detailed study of the spectrum of α Persei with high dispersion by Dunham, the classification of the spectra of the separate components of double stars by Leonard, and the continuation of observations of the spectra of faint stars in the Selected Areas by Humason. In α Persei about 1800 lines were measured, more than 90 per cent of which have been identified, and the measurement of their absolute intensities is in progress.

The absolute magnitudes of about 400 stars of types K3 to K8, including both giants and dwarfs, have been determined by Adams, Joy, and Humason by the spectroscopic method. Strömberg has made an investigation of the values for the giants and a determination of their probable errors. Twenty-eight of the stars may be classed as supergiants with a mean absolute magnitude of —1.4. The remaining giants have a magnitude of —0.1 and show a dispersion of 1.3 magnitude.

Special investigations have been made of faint components of stars of large proper motion, and of the Cepheid variables. The results so far obtained for the Cepheids indicate that absolute magnitudes can be derived by an extension of the reduction system employed for ordinary giants of similar spectral type. A close correlation seems to exist between spectral type and absolute magnitude.

Russell and Adams have used the high-dispersion spectrograms of bright stars in an investigation of the amounts of metallic vapor present above stellar photospheres, and of the temperatures and other physical conditions in stellar atmospheres. The results indicate a serious departure from thermodynamic equilibrium in stellar atmospheres, which results in an apparent excess of the number of atoms in excited states. After correction for this anomaly, temperatures are derived, which

agree closely with those found by other methods. The amounts of metallic vapor above equal areas of the photosphere of the cooler c-stars like α Orionis seem to be of the order of 100 times as great as in the case of the sun; and the strength of the enhanced lines in such stars suggests that they are produced largely in extensive chromospheres supported by radiation pressure.

The measures of stellar radiation accumulated by Pettit and Nicholson have been completely reduced, and the results applied to the computation of the absolute bolometric magnitudes, temperatures, and diameters of a considerable number of stars. Betelgeuse and Antares are found to have the brightest radiometric magnitudes, followed by Sirius, Canopus, and γ Crucis. Stars of low temperature do not, in general, radiate like black bodies, the deviation in the case of long-period variables amounting to 2.5 mag. in heat-index, and 0.4 mag. in water-cell absorption. Several of these variables at maximum have computed diameters ranging from 0″.022 to 0″.047. The calculated diameter of Sirius is 0″.005, of Procyon, 0″.007, and of Capella A, 0″.011.

Measurements of the diameter of Betelgeuse by Pease with the 20-foot interferometer gave a value of 0″.037 for the epoch, February 1928.

In the Physical Laboratory, King has made extensive investigations of the spectra of several of the rare earths. This work has included the measurement of the wave-lengths of several thousand lines, mainly on spectrograms taken with the electric furnace; the separation of the lines of the neutral from those of the ionized element; their temperature classification; and a special study of many of the complex lines, especially of praseodymium, with high dispersion. The ultra-violet spark spectrum of the doubly-ionized atom of each of these elements has also been investigated. Frequent use has been made of the method of suppressing the enhanced lines by introducing into the electric furnace an element like caesium of still lower ionization potential. These investigations have been of great assistance in the identification of rare earths in the solar spectrum.

An analysis of his measurements of the displacements of iron lines under pressure has enabled Babcock to define the change of level of the various spectral terms produced by a difference of one atmosphere in the pressure at the source of light. The Mount Wilson classification of spectral lines has thus been given a numerical basis. A difference of one temperature class in the furnace classification of King corresponds to a change of about 0.7 volt in the excitation potential, except in the case of calcium, where it is 0.35 volt.

Anderson has studied the strong continuous spectrum shown by vacuum tubes through which a heavily condensed discharge is passed. With voltages of 3,000 to 35,000 volts he finds, at a current density of about 20,000 amperes per square centimeter, a sort of "saturation" value beyond which the increase in intensity of the continuous spectrum with

current is slight. At current densities less than 10,000 amperes per square centimeter the continuous spectrum is practically absent. These results are for an initial gas pressure of 0.5 mm of mercury in a tube 10 cm long viewed end-on. A promising method is thus afforded for determining the absorption coefficient of gases at high temperatures.

An attempt has been made by Smith to produce in the laboratory the forbidden lines of ionized oxygen and nitrogen found in the spectra of gaseous nebulae. Vacuum tubes of various forms excited in many different ways were tried, but the forbidden lines did not appear.

Pettit's laboratory investigations included the measurement of the radiation of arc lamps in the ultra-violet region $\lambda\, 0.29\, \mu$ - $\lambda\, 0.31\, \mu$, the optical properties of fused and crystalline quartz, and photochemical changes in glass.

The study of fused quartz lenses shows that a reticulated structure is present, due probably to the fusion surface of the crystals used in their manufacture. In some cases, the chief effect is scattered light in the image, but in others where striae are seen multiple images are produced.

Additional laboratory investigations have included King's work on ultra-violet arc and spark spectra of several elements, the principal neutral and enhanced lines of erbium, and the line and band spectra of boron; Babcock's revision and compilation of standards of wave-length; Smith's successful development of a long-period vertical seismometer; and several studies by Pettit of photochemical changes in the ultra-violet transmission of glass, and the transmission of organic liquids and filters in the ultra-violet or infra-red.

Strömberg and Pease have repeated the experiment of Esclangon, made in 1927, which appeared to indicate the existence of an ether-drift or of a non-isotropic character to space. Their apparatus was mounted on a turntable floating in mercury and was rotated slowly in one direction and then the other. The displacements of the fringes were found to be extremely small, seldom exceeding 0″.02, and did not seem to be in any way systematic. Esclangon's values showed an amplitude of 0″.05 and varied with the sidereal time.

Attempts to use the 82-mile base-line between Mount Wilson and Mount San Jacinto for measurements of the velocity of light were interfered with so seriously by smoke and haze that Dr. Michelson decided in June to move the distant station to Santiago Peak, about 50 miles from Mount Wilson. Conditions thus far have been unfavorable for observations. In the meantime Dr. Michelson has devised a method for carrying on the measurements in a pipe line exhausted of air, about half a mile in length.

Observations have been continued by Michelson, Pearson, and Pease on the ether-drift experiment, and the apparatus has been used in a variety of forms. Several hundred measures made with the 11-foot rotating steel and invar interferometer showed no displacement of the kind observed by Professor Miller, which varied with sidereal time,

but residual disturbances amounting to several hundredths of a fringe were found, which were ascribed to a combination of temperature effects and strains in the interferometer frame. The interferometer was then set up on a 100-inch cast-iron plate floating in an annular tank filled with mercury. The apparatus was enclosed in a double room and observations were made from without. The measurements of Pearson and Pease give a negative result even more decisively than before, and show that the disturbing factors have been almost completely eliminated.

W. S. ADAMS, *Director.*

UNITED STATES NAVAL OBSERVATORY

WASHINGTON, D. C.

Changes in the staff. CAPTAIN E. T. POLLOCK, U.S.N., after nearly four years as Superintendent, relieved by CAPTAIN C. S. FREEMAN, U.S.N. CAPTAIN A. H. RICE, U.S.N., appointed Assistant Superintendent. Material Department (Naval): COMMANDER I. H. MAYFIELD, U.S.N., reported for duty; COMMANDER W. O. WALLACE, U.S.N., LIEUT.-COMMANDER D. B. DOWNER, U.S.N., and CHIEF ELECTRICIAN E. H. BELKNAP, U.S.N., relieved; COMMANDER A. G. STIRLING, U.S.N., LIEUT.-COMMANDER W. D. CHANDLER, U.S.N., and CHIEF ELECTRICIAN C. H. SNOVEL, U.S.N., transferred to sea duty. Astronomical Department: ASSISTANT ASTRONOMER ISABEL M. LEWIS, JUNIOR ASTRONOMERS GLEN H. DRAPER, CHARLOTTE KRAMPE, ARTA H. HADFIELD, BEVAN P. SHARPLESS, NICHOLAS E. WAGMAN appointed; ASSISTANT ASTRONOMER JAMES D. WISE resigned. Deaths: W. D. HORIGAN, LIBRARIAN, 42 years service; C. S. LEWIS, ASSISTANT ASTRONOMER; G. A. HILL, ASTRONOMER, 38 years service; COMMANDER HARRY KIMMELL, U.S.N.

Navigation. The speed of modern ships, their increasing numbers, the keenness of commercial competition, and the development of aerial navigation (avigation) require, with increasing insistence, that navigational instruments and methods be brought to a perfection and precision undreamed of a few years ago. The essential developmental work in connection with nautical instruments of precision is one of the important functions of this observatory.

Time. Official time for the United States has been furnished to the radio stations at Arlington, Annapolis, San Diego, and Key West, at 3:00 A.M., noon, and 10:00 P.M., 75th meridian time. All three are habitually emitted by radio from Arlington on 4,015 and 8,030 kilocycles, modulated wave. Other pertinent data as to the time service can be obtained on application to the superintendent.

Ephemeris Department. Beginning with the volume of the *American Ephemeris* for 1931, the sun's longitude will be referred to the mean equinox of the beginning of the year instead of to the true equinox of date; the sun's latitude will be given referred to the ecliptic of the beginning of the year and referred to the ecliptic of date; the sun's rectangular coördinates will be referred to the mean equator and equinox of the beginning of the year; the values of the Besselian star numbers will be given, as well as their logarithms; in the computation of eclipses, the longitude of the sun from Newcomb's Tables will be increased 1".5; and in the computation of the elements for the prediction of occul-

tations the mean longitude of the moon from Brown's Tables will be increased 7".0 as has been done in the computation of eclipses for a number of years.

Work on the new zodiacal catalogue is continuing. An intercomparison in ten representative catalogues has been made to determine the systematic differences to be used in obtaining normal positions approximately at the epoch 1905. A similar set of normal positions, for the approximate epoch 1915, is being formed for the zodiacal stars of the Backlund-Hough list based on five catalogues of the Cape of Good Hope, Greenwich, Paris, Pulkowa, and Washington Observatories. Another set of normal positions will be formed from the observations now being made at the Cape and here.

Progress has been made on the study of the declinations of about fifteen catalogues included within the epoch 1880-1900, with a view to forming a normal system of declinations for the epoch 1890.

Work on the investigation of the orbits of Saturn's satellites is proceeding slowly.

Meridian Astronomy. Of the 72,330 observations secured with the 9-inch transit circle during the period 1913-1926, the apparent star places are now nearly reduced and the mean places are reduced to 1920. The observed magnitudes of the 10,000 stars of the catalogue have been derived, using the scale equivalent of the screen system, based on a comparison of 20,000 observed magnitudes with the Harvard photometric magnitudes. An absorption of 0.45 mag. ($sec\ z - 1$) and corrections for the different observers were applied.

A new program of work for the 6-inch transit circle was begun and is planned for approximately six years. Besides observations of the sun, moon, and planets, the program will include observations of about 3,500 zodiacal stars, about 2,500 selected standard stars, about forty selected stars for refraction, also Ceres and Vesta, and Eros at the opposition of 1930-31. The zodiacal stars include those in Gill, Hedrick, and the Backlund-Hough list, and, in addition, all others of magnitude 7.0 or brighter. They will be observed four times each in the first two years, if possible. Some minor improvements to the instrument have been made.

A new program of work for the altazimuth instrument was also begun and is planned for approximately five years. The program contemplates declination observations of the sun, Mercury, Venus, Ceres, Vesta, and the stars of the list in Volume X, Part 1, *Astronomical Papers of the American Ephemeris and Nautical Almanac.* The program purposely interlocks with the current 6-inch transit circle program.

Observations with the photographic reflex zenith tube have been continued for the determination of variation of latitude, the aberration constant, and eventually the nutation constant. The observations for the past year number 1,912.

Equatorials. Observations of the positions of satellites, occultations,

asteroid and comet positions, and eclipses of the satellites of Jupiter have continued to occupy the 26-inch and the 12-inch equatorials. The latter instrument is available to the public one night a week for a period of about two hours.

Astrographic Work. Observations of the sun with the photoheliograph were made on 279 days, solar spots or groups being found on each of these days. Many enormous groups have appeared during this period, and it seems probable that a sun-spot maximum will occur the latter part of 1928. Publication of the current solar observations in the *Monthly Weather Review* has been continued, Harvard Laboratory, Yerkes, and Mount Wilson supplying dates missed by the Naval Observatory.

The 10-inch photographic telescope (triplet) is undergoing needed repairs and improvements, including rigorous re-adjustment of its pair of photographic objectives. The regular program of securing data for determining and improving the orbits of asteroids and for the determination of the solar parallax will be resumed shortly, as will certain experimental work in obtaining positions differentially.

Tentative plans have been made, after extensive consultation with leading American astronomers, for amplifying the astrographic work of the Naval Observatory along astrometric lines.

Publications. Volume XI, *Naval Observatory Publications,* second series, *Six-inch Transit Circle Observations, 1909-1918,* was received from the printer in January, 1928. Volume XII, *Naval Observatory Publications,* second series, *Equatorial Observations, 1908-1926,* has been delayed in publication through lack of funds. Advantage has been taken of the delay to include the Washington-San Diego world longitude determination observations. The volume is now in the hands of the printer, being prepared for issue.

The *American Ephemeris* for 1930 has been printed; that for 1931 is now in the hands of the printer. The *American Nautical Almanac* for 1930 is in type.

Miscellaneous. An addition of ten computers to the force of the Observatory has been one of the most valuable incentives to accomplishment that has occurred in the institution in many years. This help came at a critical time when the fundamental work in astronomy was suffering through the inability of the computers to keep reasonably up to date in the reduction of observations.

C. S. FREEMAN, CAPTAIN U. S. N., *Superintendent.*

PRINCETON UNIVERSITY OBSERVATORY

PRINCETON, NEW JERSEY

Mr. Russell has continued his spectroscopic work. An analysis of the arc and spark spectra of yttrium has been completed, in collaboration with Dr. Meggers, and is now in press. A shorter paper on the spark

spectrum of oxygen has been published (*Physical Review,* **31**, 27-33, 1928) and one in collaboration with Professor Shenstone on a method of reducing prismatic spectra (*J.O.S.A.* and *R.S.I.,* **16**, 298-300, 1928).

In the field of astrophysics, he has published a theoretical discussion of the determination of dynamical parallaxes of binary stars, with the aid of Eddington's mass-luminosity relation (*A.J.,* **38**, 89-99, 1928). The dynamical method, in the case of binaries for which orbits are available, should give more accurate results than can now be obtained in any other way, except for the nearest stars. For the "physical pairs" in which the periods are probably thousands of years and only the apparent distance and rate of motion are known, the dynamical parallaxes have a probable error of about thirty per cent of their values, and are nearly comparable in accuracy with spectroscopic parallaxes. A catalogue of dynamical parallaxes, including more than 1600 stars, is now in course of preparation by Mr. Russell and Miss Moore.

A short paper on the advance of periastron in eclipsing binaries points out a method for attack on the otherwise intractable question of the degree of internal concentration of the stars, and shows that for Y Cygni—the only star for which data are now available—the central density is not as high as has sometimes been suggested (*M.N.,* **88**, 641-643, 1928).

Other investigations by Mr. Russell are summarized in the Mt. Wilson report.

Mr. Dugan has continued his observation of the eclipsing variables SX Cassiopeiae, Y Cygni, U Coronae Borealis, TY Pegasi, RT Persei, and W Ursae Minoris.

Light curves of X Trianguli and RT Sculptoris were published (*P.U.O. Contributions,* No. 8). For both stars spectrographic observations were furnished by the Mt. Wilson Observatory. For the former star it was quite definitely established that the limb brightness is one-third that of the center. In the latter, serious difficulties encountered in obtaining a satisfactory solution indicate that further observations of the short-period eclipsing variables should be made.

With the aid of a long series of observations from the Harvard plates he and Mr. W. F. H. Waterfield were able to make more definite the variation in the period of Y Cygni and to make it reasonably certain that the variation is caused by a revolution of the line of apsides (*Harvard Bulletin,* No. 856).

Mr. Stewart, with the assistance of Mr. S. A. Korff, a graduate student, has established an "astrophysical laboratory" in rooms generously provided by the Physics Department. Measurements of the refractive index and opacity of vapors are now being made (in continuation of work described in *Physical Review,* October, 1928). It is evident that the classical theory of these matters yields equations which are sufficiently reliable for useful application to such astrophysical problems as the width of Fraunhofer lines. The chief process in accounting for

their width is a modified Rayleigh scattering. For wave-lengths near "absorption" lines such scattering is not inversely proportional to the fourth power of the wave-length, but is greatly intensified by the increase there, of $(\mu - 1)^2$, where μ is the refractive index. This increase accompanies "anomalous dispersion."

HENRY NORRIS RUSSELL, *Director.*

ASTROPHYSICAL OBSERVATORY

SMITHSONIAN INSTITUTION

WASHINGTON, D. C.

The three field stations are now steadily sending results of daily observations of the intensity of solar radiation. The work of comparing these observations, of detecting and determining sources of error, and correcting therefor, and the care of keeping the three stations supplied with material and personnel has occupied much time of the director and staff in Washington. The computations are under Mr. Fowle's direction.

A new form of pyrheliometer has been constructed to measure more accurately and conveniently the sun's radiation. There are two or three slight sources of error, and a certain slowness of reading characteristic of the silver-disk instrument, which it is hoped to improve upon. Thus far the new instrument, of a compensating electrical type, has not quite reached expectations, but it is still hoped to overcome its deficiencies and retain its advantages.

Attention was also paid to the improvement of the radiometer for measuring the energy of the stars.

In connection with a research by Mr. Aldrich on the radiation and convection of the normally clothed human body, a number of instrumental appliances were also made. A grant of $1,000 was made by the New York Commission on Ventilation to the Smithsonian to promote this research. Mr. Aldrich undertook the work and made several long series of novel and valuable experiments, the results of which will shortly be published.

As far as possible, daily measurements of the intensity of solar radiation have been made at the stations in California, Chile, and South West Africa. Pending completion of the statistical investigations of the results of the two last-named stations, only the results obtained at Montezuma are being published at present. By continued coöperation of the United States Weather Bureau, the daily telegraphed values of the solar constant of radiation are being regularly published on the Washington daily weather map.

As tentatively and privately forecasted in November, 1927, on the basis of hitherto observed periodicities in solar phenomena, the "solar constant" values reached a high level in the spring months of 1928, and were expected to reach a low level in the autumn. Much interest at-

taches to these tentative forecasts of the solar energy for long periods in advance, but several years must yet elapse before (if ever) they can be made with sufficient confidence to justify publication.

By aid of a grant from Mr. John A. Roebling, the Montezuma station was equipped with the necessary apparatus for determining the quantity of atmospheric ozone by the spectroscopic method perfected by Dobson. For about one year daily measurements were made at Montezuma by Field Director Freeman, aided by Mrs. Freeman. The photographs taken were reduced in England by Dobson and his colleagues, but, contrary to European experience, showed almost zero variation. They also showed a much smaller quantity of atmospheric ozone at Montezuma than in Europe.

Finding further observations at Montezuma unnecessary because of the uniformly constant results, the apparatus was returned to Oxford, restandardized, and sent to Table Mountain, Calif., where it is now installed for daily observing.

The writer undertook at Mount Wilson, in the autumn of 1927 and summer of 1928, to continue radiometer measurements of the distribution of energy in the spectra of the stars. It had been proposed to substitute hydrogen for air in the radiometer, on the theory that the radiometer reaction would be nearly the same, but the damping and consequent sluggishness of action would be much diminished in so light and free-moving a gas as hydrogen.

For use in 1928, at Dr. Adams's suggestion, there was prepared an optically figured quartz cylindrical vessel. This fused quartz cylinder, of beautiful clearness, was made to my order by the General Electric Co., and was figured within and without at the Mount Wilson Observatory shop. Being truly a circular cylinder with optically figured concentric walls, it mattered not at all in what direction the radiometer looked out. Thus by mounting the whole cylinder from a brass support, rotatable in a ground joint, the radiometer could be inclosed in an airtight outside case of brass having windows, toward which the radiometer could at any time be made to look out by merely rotating the brass piece in its well-ground seat.

With this simple but adequate apparatus the Mount Wilson expedition was renewed by the writer in 1928, with a high degree of success.

C. G. Abbot, *Director.*

VAN VLECK OBSERVATORY

Wesleyan University

Middletown, Connecticut

Of the 748 plates taken during the year, 656 were for stellar parallax determinations, chiefly of stars from the 9th to the 11th magnitude with large proper motion. Mr. Stearns has derived the parallaxes for twenty stars.

The comet discovered by Mr. Stearns in March, 1927, is still being followed at the Yerkes Observatory.

Messrs. Slocum and Stearns have completed an investigation of the effects of atmospheric dispersion upon stellar parallax determinations (*Publ. A.A.S.*, **6**, 124, 1927).

A study of the weather conditions along the path of the total eclipse of the sun of August 31, 1932, is being made at about 100 stations between the Hudson Bay region and Cape Cod, Massachusetts. Observations are made at 3:30 P.M., Eastern Standard Time, from August 15 to September 15 of each year. The results are being sent to this observatory for tabulation and discussion. Records for the years 1925, 6, 7, 8 have thus far been received.

Messrs. Slocum and Sitterly have given four year-courses and one half-year course. Mr. Stearns has devoted all his time to research. Mr. N. E. Wagman, who has been student assistant, has received his M.A. degree and has accepted a position as Junior Astronomer in the U. S. Naval Observatory.

Mr. Slocum attended the meetings of the International Astronomical Union at Leiden and of the Astronomische Gesellschaft at Heidelberg.

FREDERICK SLOCUM, *Director.*

WASHBURN OBSERVATORY

UNIVERSITY OF WISCONSIN

MADISON, WISCONSIN

The equatorial mounting for a 10-inch photographic objective was completed in the University shops. This instrument will be used for experimental work in photo-electric photometry. The driving clock and other parts for a new mounting of the 15-inch refractor were also completed under the direction of Mr. O. E. Romare.

The 15-inch refractor was used on ninety-eight nights by Messrs. Stebbins and Huffer for the regular photometric program on red stars, spectroscopic binaries, and known variables. About two hundred red stars have now been tested, and the results confirm the previous conclusion that most of the stars of bright absolute magnitude or of extreme redness, classes M4 to M6, are variable to the extent of a tenth of a magnitude or more. Following is a list of the more interesting variable stars on the program, with the present state of the observations:

α Orionis. Many measures each season, 1916-1928.
α Herculis. Many measures each season, 1918-1928.
ψ^1 Aurigae. Irregular variable; measures each season, 1919-1928.
β Persei. Miscellaneous determinations of times of minima, 1921-1928.
31 Camelopardalis. Eclipsing variable; light-curve complete.
β Lyrae. New series with six comparison stars completed.
η Orionis. Eclipsing variable, period very nearly 8.0 days; many observations, 1916-1928.
H. D. 25833. Eclipsing variable; light-curve complete.
RR Lyncis = Boss 1607. Eclipsing variable; light-curve nearly complete.

Boss 5070. Eclipsing variable; light-curve about three-fourths complete.
H. D. 216014. New eclipsing variable, range about 0.2 magnitude; light-curve about half complete.
H. R. 7165. New Cepheid variable, range 0.4 magnitude, period 4.471 days; light-curve about three-fourths complete.
ε Aurigae. Observations beginning January, 1928. This star will be followed through the present minimum lasting two years.

Volume 15, Parts 1 and 2, of the *Publications of the Washburn Observatory* were distributed during the year. Additional parts are in preparation.

In July and August, 1927, Mr. Stebbins spent some weeks at Mount Hamilton and continued the work of a year previous on a test of the solar variation by photometric measures of the satellites of Jupiter and of the planet Uranus. The results were published in collaboration with T. S. Jacobsen as a *Lick Observatory Bulletin*.

The American Astronomical Society held its annual meeting at Madison in September, 1927.

JOEL STEBBINS, *Director*.

YALE UNIVERSITY OBSERVATORY

NEW HAVEN, CONNECTICUT

Mr. Slavenas terminated his second year as Fellow of the International Education Board in December and became Sterling Fellow for the remainder of the academic year, receiving his doctorate in June. Mr. Dirk Brouwer was in residence at the Observatory as Fellow of the International Education Board from September 15 to January 15. Mr. Kerrich, junior lecturer in mathematics at the University of the Witwatersrand, has assisted in a voluntary capacity in the measurement of plates at Johannesburg.

Our office building having become crowded, an extension on the east side of the building has been built, thus completing the original plans designed in 1881. The addition contains six office rooms and a small lecture hall.

Continuing our experiments with fields of very large angular extent, forty-two plates out of the total of forty-eight that are necessary, with centers at 25°, were secured by Mr. Schilt with the Catalogue Camera. By the close of the year, fourteen of these plates had been completely measured and another had been partly measured. These measures refer to about 12,700 star images, or thirty per cent of the total number of stars in the two Gesellschaft zones that the plates cover. Twenty-four plates were reduced, the procedure that we are employing enabling us to reduce the plates before they are measured, except for a final step. The measurement of the plates had to be interrupted when the building operations were begun.

Mr. Schilt has completed all the preliminary work necessary for the determination of photographic magnitudes of the same stars and has secured nineteen definitive plates out of the total of forty-eight that the

whole work will require. It was at first intended to use the same plates for magnitudes that we are using for positions, but it was found to be better to use plates of smaller scale. Mr. Schilt then tried a Zeiss anastigmat of forty-three centimeters focal length, but this did not cover the field sufficiently well. Accordingly, a Ross camera lens of seventy-six millimeters aperture and fifty centimeters focal length has been mounted on the counterweight end of the declination axis of the Catalogue Camera, and it is with this camera that these photometric plates are being secured.

Comparison positions in the zone 55° to 60° were received from Dr. Hins, of the Leiden Observatory. They have been used to determine the constants of the seventy-two plates in this zone, and the definitive right ascensions and declinations will be published in the form of a catalogue corresponding to the Gesellschaft Catalogue within a few months.

We are indebted to Harvard College Observatory for the determination of the spectra of faint stars in the zone 50° to 55°. These data, together with those in the Henry Draper Catalogue, provide the spectra of practically all the stars in this zone and are indispensable for a complete discussion of the proper motions that appear in Volume 4 of the *Transactions* of Yale Observatory.

Miss Pond has kept up to date the card catalogue of stellar parallaxes, which includes determinations by all reliable methods. Miss Gesler has kept up to date a card catalogue of radial velocities.

Mr. Brown has continued his work on various problems in celestial mechanics, including the preparation of a treatise on this subject with the collaboration of Mr. Shook. He has also continued the reduction and discussion of occultations of stars by the moon, and has enlisted for this work the coöperation of many amateur and professional astronomers in this country and abroad.

Mr. Schilt has continued his investigation of the rotation of our galaxy by the discussion of nearly 12,000 proper motions, published by Gyllenberg, in the zone 35° to 40°, and of nearly 9,000 proper motions, published by Prager, in the zone 31° to 40°. These confirm the results derived by Lindblad and Oort and show pretty conclusively that the hypothesis made by the former is essentially correct. Incidentally, the same proper motions show the peculiarity noted last year by Mr. Schilt from a study of the stars in the equatorial zone, the giant stars exhibiting a different motion in space from those in the regular sequence.

At our request, Dr. H. Spencer Jones kindly secured for us at the Cape of Good Hope an extra-focal plate of the globular cluster Omega Centauri, which Mr. Schilt has measured with his microphotometer. These measures show almost precisely the same distribution of light as Hertzsprung found for the globular cluster Messier 3. The two objects would look almost exactly the same if Omega Centauri were removed to 5.3 times its present distance. It is planned to extend the same research

to four other globular clusters.

Mr. Slavenas completed his study of the stellar case of the problem of three bodies. This has been printed in Volume 6 of our *Transactions* and forms his dissertation for the doctorate. He has applied this theory to the case of Lambda Tauri ("A Note on the Triple System, λ Tauri," *Proceedings of the National Academy of Sciences*, **13**, 833). From ninety-seven plates secured by Mr. Schilt at Mount Wilson in 1925 and 1926, Mr. Slavenas has determined the light curves of seventeen variables in the cluster Messier 3. He expects next year from the same plates to determine light curves of about thirty additional variables, and for still another thirty stars to determine corrections to the elements. From seventy-five plates which he secured with a small camera attached to our Catalogue Camera, Mr. Slavenas has made a photometric study of Uranus. This shows that while there is obviously a variation in the brightness of Uranus, the change is smaller than has been obtained by some other observers.

The American Astronomical Society met at New Haven on December 29 and 30, and on the following day there was a meeting of the American Section of the International Astronomical Union.

During the ten months ending with April 30, fourty-four per cent of the nights at Johannesburg were clear, thirty-five per cent were partly clear, and twenty-one per cent were cloudy. In the three years that the station has now been in operation, the sky has fulfilled our expectations both with regard to the amount of clear weather and as to the high quality of the steadiness of the atmosphere.

During these ten months, 3989 plates were secured. Of these, 3868 are for the determination of parallaxes and proper motions, fifty-nine are photographs of the Selected Areas, thirty-eight are of regions surrounding Cepheid variables, eighteen are of Jupiter's satellites, and six are of miscellaneous objects.

Since we are aiming to secure an average of twenty plates for a determination of parallax, we are now obtaining material for considerably over two hundred parallaxes per annum. This is about equal to the total number of plates secured at all the northern observatories engaged in similar work. There is therefore good reason to hope that within a few years our knowledge of stellar distances in the southern skies will be brought up to approximate equality with that in the northern; at present only twelve per cent of reliable determinations of this kind refer to stars south of the equator.

A measuring engine of appropriate type was made in the Observatory shop in New Haven and forwarded to Johannesburg, reaching there about October 1, 1927. From measures made with this engine by Dr. Alden at Johannesburg and from measures made at New Haven on plates forwarded from Johannesburg, it appears that the average probable error of a good plate is 0″.022, indicating a satisfactory degree of precision.

FRANK SCHLESINGER, *Director.*

YERKES OBSERVATORY

UNIVERSITY OF CHICAGO

WILLIAMS BAY, WISCONSIN

Personnel. Mr. Ross returned in August, after an absence of about three months at Mount Wilson, during which he photographed Venus and Jupiter.

Professor F. E. Carr, of Oberlin, photographed the Kapteyn fields of declination 45° with the twin Ross objective, photographic and photovisual, during his stay at the Observatory in July and August.

Mr. Bobrovnikoff continued his studies of comets during the summer quarter and left for the Lick Observatory on September 9.

Miss Calvert returned from her summer vacation in Europe in October.

Mr. Otto Struve was absent from October 27 to December 19 for the further study at the Harvard Observatory of calcium in space.

Mr. Van Biesbroeck attended the meeting of the International Astronomical Union at Leiden.

Professor Georg Struve, of the University of Berlin and of the Observatory at Neubabelsberg, spent the summer as guest of the Observatory for micrometric observations, chiefly of the satellites of Saturn and Uranus.

Professor W. H. Garrett, of Baker University, was again assistant during the summer, working on his photometric problem at the 24-inch reflector.

Dr. Arthur S. Fairley joined the staff, June 18, 1928, and was assigned work with the U-V telescope in the determination of the photographic brightness of the brighter stars.

Equipment. The polar head and the new double tube for the twin 12-inch telescope came back from Fecker's shop on June 18, 1928, and work on the erection of the instrument was in progress at the end of the period of this report.

A new correcting lens of 6 inches aperture was designed by Mr. Ross and constructed by J. W. Fecker. It is a two-lens system, and is placed 250 cm in front of the slit of the Bruce spectrograph. A steel frame, swinging like a gate within the tube of the 40-inch telescope, was constructed by Mr. Ridell to carry this lens. Mr. Moffitt assisted in the design of this permanent attachment to the large telescope.

In order to secure more precision in the focusing of plates in the Bruce spectrograph, a set of 6 new plate holders was made of bronze castings by Mr. Ridell. They permit a focusing to about 0.03 mm. Four small plate holders of stainless steel were constructed by Mr. Ridell for use with the short-focus Moffitt lens of the spectrograph.

Reversible cages for fixing and washing 8x10 parallax plates were designed by Mr. Moffitt and built of Monel metal.

For the further protection of the interests of the Observatory, the University purchased an additional acre of ground, including a house and cottage, west of our present holdings on the State Highway.

Weather Conditions. Conditions for observing were much better than in the two preceding years, as indicated by the table of actual nocturnal observations with the 40-inch telescope, together with the departure from the monthly normals for the past 25 years. The increase of about 40% certainly represents an encouraging improvement.

1927	Hours	Dep.	1928	Hours	Dep.
July	96	—45	January	152	+20
August	148	— 3	February	137	+17
September	138	—13	March	146	+19
October	187	+21	April	115	— 3
November	69	—62	May	101	—14
December	145	+18	June	66	—54
				1500	—99

Solar Work. Observations with the Rumford spectroheliograph were made by Mr. Moffitt, assisted by Mr. Morgan, 188 spectroheliograms being obtained on 38 days; 33 direct photographs were made with the 40-inch telescope. Some advantage was found in increasing the width of the second slit, in securing increased exposure and for the avoidance of possible erroneous results from motions in the line of sight. It was found that fine details could be better recorded with Eastman Process plates than with the faster emulsion usually used, partly because of greater opportunity for development. Two hundred and two photographs were taken on 115 days, chiefly with the 5-inch telescope by Mr. Morgan or Mr. Hujer. Where possible the heliographic positions of the spots were sent to the Naval Observatory.

Observations with the 40-inch Telescope. Micrometric. Mr. Van Biesbroeck made 346 measures of double stars on parts of 26 nights. He obtained 51 observations for position, brightness, and physical appearance, of 6 different comets. He made 401 estimates of the brightness of variable stars, chiefly from the list of those discovered by Mr. Ross.

Professor Georg Struve began systematic observations of the satellites of Saturn on June 11.

Astrometric. Four hundred and twenty-three plates suitable for stellar parallax were obtained on parts of 85 nights, 311 by Mr. Moffitt, 105 by Mr. Morgan, and 7 by Mr. Van Biesbroeck. This number includes 18 plates taken for determination of proper motions. About 120 stars have been added to the observing program, chiefly from the list of proper motion stars discovered by Mr. Ross and having motions between 0″.3 and 0″.5 per annum. The plates for the first epoch have been taken for a number of these stars, while for a few the second epoch has been obtained. Four series of plates have been completed and the

plates measured by Mr. Moffitt. Investigation of the development for parallax plates has been continued by him with the result that the exposure time has been reduced to one-third of that used two years ago.

Spectrographic. The Bruce spectrograph was used on the whole or parts of 124 nights and 614 spectrograms were obtained, 337 by Mr. Struve, 152 by Mr. Barrett, 49 by Mr. Pogo, 44 by Mr. Hujer, and 32 by Mr. Morgan. Of these 163 had the dispersion of 3 prisms, the remainder that of one prism. 1970 spectrograms were measured as follows: 1668 by Mr. Struve, 122 by Mr. Pogo, 78 by Mr. Hujer, 56 by Mr. Chang, and 46 by Mr. Morgan.

Most of the measures by Mr. Struve were made in completion of the program on the radial velocities of 500-A stars, long under observation here. Mme. Elisabeth Struve worked throughout the year on the computations in this department. The reductions are completed and the early publication of this work is planned. Mr. Struve found remarkable variations in the spectrum of the A-star 17 Leporis, somewhat similar to those in α Canum Venaticorum, but more pronounced.

Orbits of the following spectroscopic binaries were computed:

4 β Trianguli	Struve and Pogo
30 τ Canis Majoris	Struve and Pogo
13 Ceti	Pogo new orbit
η Orionis	Pogo revision
31 Crateris	Struve new period from Ottawa observations
36 τ^9 Eridani	Hujer revision
ζ Herculis	Chang visual double
6 β Delphini	Chang visual double

Considerable time was given to the observations with 3 prisms of the standards for radial velocity which have been followed here for many years. Measures were completed for all unmeasured plates prior to 1928 and accurate wave-lengths were derived for all the stars on the list. Observations were also begun of the new list of standard velocity stars drawn up by the subcommittee of Commission 30 of the International Union. A study was made of possible sources of error in determination of radial velocity with high dispersion and improvements were made in the focusing of the instrument.

Mr. Struve continued his study of the remarkable 27 Canis Majoris. With the aid of data from the Chile station of the Lick Observatory, it was proven that the period cannot be one day, but must be 3 years or more. And it seems impossible to escape the conclusion that its mass is of the order of one thousand times that of the sun.

Mr. Pogo developed an improved form of the Laves hodographic method of determining the orbit of a spectroscopic binary and in his doctor's thesis made a new investigation of the spectroscopic orbit of 13 Ceti.

Mr. Hujer continued his studies of the silicon and strontium lines in stellar spectra. Some preliminary results were presented to the American Astronomical Society.

A new table for the reduction of one-prism spectrograms was computed by Mr. Struve and Miss Cable.

24-inch Reflector. The work on asteroids needing reobservation was continued by Messrs. Van Biesbroeck, Struve, and Chang and 149 plates of comets were taken together with 327 plates on asteroids. On parts of 108 nights, 99 positions were obtained for 53 asteroids. A new asteroid YO 26 was found by Mr. Van Biesbroeck and adequately observed.

Fifty-two plates for cometary positions were obtained by Mr. Van Biesbroeck yielding 5 positions of periodic comet Schaumasse and comet Encke in 1927, as well as the last positions of comet Pons-Winnecke and comet Schwassmann.

Bruce Photographic Telescope. Mr. Ross continued his survey for proper motion stars and published his sixth list of such stars in the *Astronomical Journal,* numbering 106 and bringing the total to 787. He also published the sixth list of 65 new variable stars discovered in the same surveys. The number of fields taken was 100. A beginning was made on photographing the Kapteyn areas from 15° south to the North Pole, using the twin cameras. At Mount Wilson, during July and August, several hundred exposures were made in various colors, of the planets Venus and Jupiter. Mr. Ross took time for a careful study of the photographs of Venus with an interpretation of the conditions in the atmosphere of that planet. This was published in the *Astrophysical Journal* for July, 1928.

General. For the safer preservation of our extensive collection of astronomical photographs, now numbering some 50,000, an attic room with brick walls in the center of the building was finished off by painting the walls and treating the cement floor to prevent dust and by providing an adequate system of lighting. A set of steel cabinets should next be provided for the filing of these negatives.

Volume 5 of the *Publications,* both parts by Mr. Van Biesbroeck, the first covering his observations of double stars for ten years, and the second, being the memoir on the definitive orbit of comet 1914 V (Delavan), was distributed.

The *Catalogue of 349 Dark Objects in the Sky,* which was published in the *Barnard Atlas of Selected Regions in the Milky Way,* was reprinted as a pamphlet of 12 pages for the convenience of workers in celestial photography.

Miss Calvert gave most of her time to the preparation for publication of Professor Barnard's micrometric measurements of the positions of selected stars in about 17 of the principal star clusters. She also prepared for Professor Aitken, for inclusion in the new extension of the β catalogue of double stars, Professor Barnard's measurements of such stars made in the seven years from 1915 until the time of his death. Miss Jorgensen assisted in both of these pieces of work.

Library. The capacity of the library was greatly increased by the opening of a second stack room in the attic, of size 80x18 feet. The room was plastered and ample electric illumination installed and was supplied with 30 steel stacks being released to us by changes at the University. The congestion caused by the accumulation of duplicates and reprints from the libraries of Professors Burnham and Barnard was relieved. The extensive work of transfer was carried out by Miss Van Biesbroeck, under the supervision of Mr. Barrett. There was the normal increase of bound books during the year.

The number of visitors during the year was 12,160.

The lavatories on the main floor were remodeled and new equipment installed. At this time a new dark room was added in the attic for the convenience of observers using the 24- and 12-inch telescopes.

EDWIN B. FROST, *Director.*

PLANET NOTES FOR APRIL.

By CLIFFORD E. SMITH.

The *Sun* will be moving northeast from the central part of Pisces to the central part of Aries. The position of the sun on April 1 and April 30, respectively, will be: R.A. $0^h\,40^m$, Decl. $+4°\,16'$, and R.A. $2^h\,27^m$, Decl. $+14°\,33'$.

The phases of the *Moon* will occur as follows:

Last Quarter	April	2	at 1 A.M.	C.S.T.
New Moon		9	" 3 P.M.	"
First Quarter		16	" 8 A.M.	"
Full Moon		23	" 4 P.M.	"

The moon will be at apogee on April 1 and April 28, and at perigee April 12.

Mercury will be moving apparently eastward from the western part of Pisces to the western part of Taurus. It will be at superior conjunction on April 17. Early in the month it will rise about an hour before the sun, and at the end of the month it will set about an hour after the sun. On April 18 it will be in conjunction with Venus, on April 28 in conjunction with Jupiter, and on April 25 will pass through its perihelion point.

Venus will be moving from the central part of Aries to the eastern part of Pisces. Thus its apparent motion in the sky will be retrograde. On April 18 it will be in conjunction with Mercury, and on April 20 it will be at inferior conjunction. At the beginning of the month it will set about an hour and half after the sun, and at the end of the month it will rise about an hour before the sun.

Mars will be moving from the western part to the eastern part of Gemini. It will have been at quadrature east of the sun on March 28, and thus will be near the meridian about 5:30 P.M., Standard Time, during the middle of the month. On April 15 Mars will be in conjunction with the moon.

Jupiter will be in the western part of Aries. Its apparent motion will be slowly eastward. On April 28 it will be in conjunction with Mercury. On this date Jupiter and Mercury will be about two degrees apart and they will set about fifty minutes after the sun.

Saturn will be in the western part of Sagittarius. Until April 9 its apparent motion will be direct; the remainder of the month it will be retrograde. During the middle of the month it will be on the meridian about 4:30 A.M., Standard Time.

Uranus will be in the southern part of Pisces. Its apparent position will be rather near that of the sun since it will have been at conjunction on March 28.

Neptune will be in the constellation Leo near the bright star Regulus. On April 18 it will be in conjunction with the moon. During the middle of the month it will be on the meridian about 8:30 P.M., Standard Time.

Occultations Visible at Washington.

[From the *American Ephemeris.*]

Date 1929	Star's Name	Magnitude	IMMERSION Washington C.T. h m	IMMERSION Angle from N °	EMERSION Washington C.T. h m	EMERSION Angle from N °	Duration h m
April 2	τ Sagittarii	3.5	5 22	127	6 35	226	1 13
3	ω Sagittarii	4.8	2 24	102	3 36	258	1 11
3	*A* Sagittarii	4.9	4 10	80	5 36	270	1 27
4	86 B. Capricorni	6.2	5 3	108	6 16	224	1 13

Occultation of BD+26°1120 by Mars. — In reporting his observation of the occultation of the star BD +26°1120, magnitude 8.8, by Mars on December 16, 1928, Mr. Joaquin Gallo says that as the planet approached the star, the star apparently became fainter and fainter until it became invisible. It reappeared as apparently of magnitude 12 when one-tenth of the radius of the planet distant. It increased in brightness and was estimated as of magnitude 9 when at a distance of one radius of Mars from the limb. He adds that the diminishing in brightness of the star should be attributed to the glare of the planet and not to its atmosphere.

Occultation of Mars.—There will be a daylight occultation of Mars on the morning of March 18. The immersion will be visible in the New England states just a few minutes after moonrise (at about 10:50 A.M. Eastern Standard Time). The time of the emersion varies from 11:30 as far south as Washington to 11:45 in Maine. The moon will be above the horizon only in the northeastern part of the United States. Mars is slightly brighter than the first magnitude.

WM. CLETUS DOYLE, S. J.

Creighton University Observatory, February 23, 1929.

Monthly Report of the American Association of Variable Star Observers, for the Month of January, 1929.

The existence of the Association as an asset to astronomy would be justified if for no other reason than the well evidenced fact that few, if any, of the specially irregular variables escape the attention of the ever alert observers who make up its rostrum. Not only was the recent drop in SU Tauri and its rise again to maximum completely observed, showing every detail of its peculiar action, but now we find that the caprices of SS Aurigae, that third member of the SS Cygni-U Geminorum class, have been closely watched by our contributing members.

An examination of these records will show that in December and January this

VARIABLE STAR OBSERVATIONS RECEIVED DURING JANUARY, 1929.

Nov. 0 = J.D. 2425551; Dec. 0 = J.D. 2425581; Jan. 0 = J.D. 2425612.

J.D. Est. Obs.	J.D. Est. Obs.	J.D. Est. Obs.	J.D. Est. Obs.	J.D. Est. Obs.	J.D. Est. Obs.
V Scl	T Cas	T Phe	W Cas	R Psc	W And
000339	001755	*002546*	004958	012502	021143a
558 9.8 Bl	595 11.5 L	552 10.0 En	596 9.0 Wy	619 10.1 Pt	616 12.6 Bw
565 10.0 Bl	596 11.6 Wy	554 9.5 Sm	603 8.9 Wy	RU And	619 13.0 Pt
575 10.8 Bl	603 11.7 Wy	561 9.3 En	608 8.8 B	013238	T Per
S Scl	608 11.4 B	562 9.2 Bl	609 9.0 Wy	589 12.6 Ch	021258
001032	608 11.8 L	563 9.0 Bl	611 8.8 Jo	597 12.7 Ch	580 8.6 Ch
529 6.8 Kd	609 11.7 Wy	565 9.2 Bl	612 9.0 Wy	611 11.8 Al	595 8.6 Ch
539 6.8 Kd	612 11.9 Wy	567 9.2 Sm	618 9.3 Bw	618 11.6 Lg	603 8.8 Wy
552 6.9 En	616 12.0 Kz	575 8.8 Bl	619 8.8 Pt	619 10.9 Pt	609 9.0 Wy
558 6.5 Bl	619 11.9 Pt	580 9.2 Dr	U Tuc	Y And	612 9.0 Wy
561 6.7 Ht	R And	584 9.4 Dr	*005475*	013338	619 8.5 Pt
561 6.9 Nz	001838	586 9.5 Dw	553 14.0 Bl	589 12.0 Ch	Z Cep
562 7.0 Kd	579 7.7 Ch	587 9.7 Dr	561 12.9 En	597 11.0 Ch	021281
565 6.9 Bl	586 8.4 Ah	591 9.9 Dr	562 12.9 Sm	611 10.2 Al	618[13.8 Sf
567 7.1 Sm	587 8.4 Ah	599 10.2 Dr	570 12.5 Sm	619 8.4 Pt	o Cet
568 7.1 Ht	588 8.6 Ah	W Scl	Z Cet	TT Per	*021403*
575 7.1 Bl	590 8.5 Ah	*002833*	*010102*	014453	536 4.1 Kd
580 7.3 Dr	595 8.3 Ch	553 12.9 Bl	619 11.1 Pt	589 8.7 Br	539 4.3 Kd
584 7.4 Dr	604 8.9 Ah	591 13.1 Dr	U Scl	608 8.5 Br	552 5.7 Kd
585 7.8 Kd	610 9.5 Sb	Y Cep	*010630*	X Cas	553 5.3 En
586 7.6 Dw	611 9.1 Ah	003179	553[13.2 Bl	014958	557 5.4 En
587 7.8 Kd	615 9.6 Sb	599 13.7 Sf	582[14.5 Dr	586 12.7 Bn	561 5.6 En
591 7.6 Dr	616 9.3 Gb	619 13.9 Bw	U And	610 12.6 Bn	562 5.4 Sm
595 7.7 Dr	619 9.2 Pt	U Cas	010940	619 12.8 Pt	562 5.8 Kd
599 8.1 Dr	622 9.7 Sb	004047	618 12.2 Lg	624 12.6 Bn	565 5.9 Kd
X And	628 9.8 Sb	601 12.6 Sb	UZ And	U Per	566 5 9 En
001046	S Tuc	609 12.3 B	011041	015254	570 6.1 Wf
556 13.0 Nz	*001862*	618 13.3 Bw	618[13.9 Wy	596 8.9 Wy	580 6.7 Ch
569 13.2 Nz	552 9.7 En	619 13.6 Pt	S Cas	597 8.8 Ch	581 6.6 Wf
589 14.1 Bf	558 9.7 Bl	RW And	011272	601 9.3 Sb	582 6.2 Kd
595 14.0 Bf	561 9.6 En	004132	580 10.3 Ch	603 9.1 Wy	583 6.0 BL
603 13.9 Bf	562 9.5 Sm	588[13.1 Ch	601 11.0 Sb	609 8.8 Wy	585 6.4 Kd
612 14.4 Bf	565 10.0 Bl	V And	602 10.7 Wy	612 8.5 Wy	585 6.1 L
T Cet	575 10.0 Bl	004435	609 11.5 Wy	616 9.1 Bw	586 6.7 Ah
001620	S Cet	556 11.8 Nz	609 10.5 B	619 8.3 Pt	587 6.5 Kd
529 6.5 Kd	*001909*	566 12.2 Nz	612 11.8 Wy	627 8.4 Bw	587 6.7 BL
536 6.5 Kd	585 10.9 L	589 13.9 Bf	619 11.1 Pt	S Ari	587 6.7 Wf
539 6.5 Kd	586 11.0 Ch	595 14.5 Bf	U Psc	015912	588 6.6 Kd
553 6.6 Kd	594 10.2 L	603 14.8 Bf	011712	619 12.5 Pt	588 7.2 Ch
562 6.7 Kd	596 10.7 Ch	612 14.9 Bf	599 12.8 Sf	R Ari	589 7.1 Lg
565 6.7 Kd	599 10.3 Sf	X Scl	611 13.7 Sf	021024	590 6.6 BL
571 6.5 Kd	607 10.1 L	*004435*	618 14.0 Sf	586 8.7 Ah	590 6.6 Kd
582 6.5 Kd	611 10.0 Sf	553 13.2 Bl	618 14.0 Lg	587 8.9 Ah	591 6.7 Wf
583 6.7 L	617 9.2 Lg	RR And	619 13.4 Pt	588 8.7 Ah	591 6.5 BL
585 6.5 Kd	618 10.0 Sf	004533	R Scl	589 9.0 Ch	592 6.8 BL
587 6.6 Kd	619 9.5 Pt	556 15.3 Nz	*012233a*	590 8.5 Ah	594 6.7 L
590 6.7 Kd	T Scl	566 15.4 Nz	529 8.2 Kd	596 9.0 Wy	595 7.2 Ch
594 6.6 L	*002483a*	589 15 2 Bf	562 7.9 Kd	598 8.2 Ah	596 7.0 Wf
608 6.5 L	580 9.5 Dr	595 15 1 Bf	585 8.0 Kd	601 8.2 Ah	598 7.6 Lg
T And	584 9.4 Dr	612 14.4 Bf	R Psc	603 8.3 Wy	599 7.0 BL
001726	586 9.5 Dw	RV Cas	012502	604 8.1 Ah	599 7.2 Ch
579 9.7 Ch	591 9.1 Dr	004746a	556 13.5 Nz	605 8.0 Ah	600 7.0 BL
595 10.8 Ch	595 9.3 Dr	618[13.7 Sf	569 11.9 Nz	610 9.0 Wy	602 6.8 BL
619 12.0 Pt	599 9.2 Dr	— Cas	589 10.0 Ch	611 8.4 Ah	608 7.0 L
T Cas	RR Scl	004746b	589 11.0 Bf	616 9.0 Gb	609 7.1 BL
001755	*002438b*	618 10.6 Sf	597 10.0 Ch	619 8.2 Pt	611 7.6 Jo
585 11.5 L	580 12.8 Dr	619 10.6 Pt	607 9.5 Al		611 7.5 Ah
590 11.3 Ch	591 12.9 Dr		611 9.4 Al		613 7.8 Gs

VARIABLE STAR OBSERVATIONS RECEIVED DURING JANUARY, 1929.

J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
o CET			R HOR			R PER			S TAU			R DOR			ε AUR		
021403			*025050*			032335			042309			*043562*			045443		
615	8.2	Lg	562	12.5	Bl	617	8.5	Lg	595	14.7	Bf	584	4.9	Dr	568	3.9	L
616	8.8	Wd	563	12.6	En	618	9.0	Bw	612	15.0	Bf	587	4.9	Dr	575	3.9	L
619	7.4	Pt	565	12.6	Bl	619	9.0	Pt	T CAM			591	5.1	Dr	587	4.0	L
S PER			567	12.6	Sm	T FOR			043065			595	4.8	Dr	601	4.0	L
021558			568	12.6	Ht	*032528*			585	11.8	L	599	4.8	Dr	R LEP		
580	9.3	Ch	575	12.2	Bl	585	8.9	L	586	11.7	An	R CAE			*045514*		
596	9.5	Wy	582	12.2	Dr	593	8.7	L	588	11.8	Ch	*043738*			583	7.8	Ch
603	9.3	Wy	587	11.9	Dr	601	8.6	L	594	12.1	L	558	11.1	Bl	585	7.1	L
609	9.1	Wy	595	10.8	Dr	608	8.7	L	597	11.9	An	560	11.5	En	591	7.9	Ch
612	9.4	Wy	599	10.4	Dr	611	8.7	L	600	12.2	Wy	561	11.7	Ht	594	7.2	L
619	8.9	Pt	T HOR			U ERI			601	12.0	L	562	11.5	Sm	600	8.2	Sb
R CET			*025751*			*034625*			609	12.4	Wy	565	11.4	Bl	608	7.4	L
022000			553	13.6	Bl	580	9.3	Dr	611	12.7	L	566	12.0	En	608	7.4	B
588	11.2	Ch	583	13.3	Dw	584	9.7	Dr	612	12.4	Wy	568	11.8	Ht	610	8.6	Sb
RR PER			584	13.0	Dr	591	10.0	Dr	617	13.0	Lg	570	11.4	Sm	611	7.3	Jo
022150			587	13.0	Dr	595	9.9	Dr	619	13.0	Pt	575	11.5	Bl	615	8.9	Sb
616	13.5	Bw	595	12.6	Dr	599	10.5	Dr	RX TAU			584	11.6	Dr	619	6.7	Pt
R FOR			599	12.5	Dr	T ERI			043208			595	11.8	Dr	V ORI		
022426			U ARI			*035124*			599	11.2	Sf	R PIC			050003		
558	10.6	Bl	030514			582	12.5	Dr	614	12.0	Sf	*044349*			587[	12.3	Ch
562	10.3	Bl	556	12.8	Nz	584	12.5	Dr	616	12.3	Wn	553	9.4	En	617	13.8	Lg
565	10.1	Bl	569	13.6	Nz	591	12.3	Dr	618	12.2	Sf	558	9.5	Bl	619	13.6	Pt
575	9.5	Bl	589	14.0	Bf	595	12.1	Dr	619	12.3	Pt	561	9.7	Ht	T LEP		
U CET			595	14.0	Bf	599	11.8	Dr	R RET			562	9.5	Sm	*050022*		
022813			599	14.1	Sf	W ERI			*043263*			563	9.8	En	556	11.2	Nz
588	11.2	Ch	612	14.5	Bf	*040725*			552	8.3	En	565	9.3	Bl	558	10.5	Bl
601	11.9	Sb	614[	14.0	Sf	582	10.3	Dr	558	8.4	Bl	568	9.7	Ht	565	10.5	Bl
619	12.3	Pt	AA PER			587	10.1	Dr	561	8.6	Ht	570	9.5	Sm	566	10.8	Nz
RR CEP			030846			591	9.7	Dr	562	8.7	Sm	575	9.2	Bl	574	10.6	Nz
022980			583	10.0	Br	595	8.9	Dr	563	8.7	En	580	8.8	Dr	575	9.7	Bl
585	10.4	L	591	10.0	Br	596	9.0	Dr	565	8.5	Bl	584	8.6	Dr	598	9.0	Bf
594	10.4	L	612	10.0	Br	601	8.9	Dr	567	8.7	Sm	591	8.0	Dr	608	8.4	B
599	10.4	Sf	X CET			RY CAM			568	9.1	Ht	595	7.6	Dr	619	8.4	Pt
601	10.3	L	*031401*			042164			575	9.3	Bl	599	7.3	Dr	S PIC		
611	10.0	L	585	8.9	L	591	8.8	Br	580	9.6	Dr	TT TAU			*050848*		
611	11.3	Sf	594	8.9	L	608	8.8	Br	584	10.0	Dr	044528			558	10.0	Bl
618	11.6	Sf	597	9.1	An	R TAU			591	10.3	Dr	583	8.5	Br	560	10.5	En
R TRI			598	8.5	Wy	042209			595	10.4	Dr	589	8.5	Br	562	9.9	Sm
023133			605	8.5	Wy	569	9.0	Nz	599	10.6	Dr	591	8.5	Br	565	10.3	Bl
589	11.6	Ch	608	9.1	L	587	9.7	Ch	X CAM			608	8.5	Br	566	10.6	En
599	11.5	Sf	610	8.5	Wy	589	10.3	Bf	043274			612	8.4	Br	570	10.3	Sm
611	11.1	Ah	612	9.2	Cl	595	10.6	Bf	588	12.1	Ch	V TAU			575	10.4	Bl
614	11.2	Sf	618	9.3	Bw	612	11.6	Bf	591	12.5	Br	044617			R AUR		
619	11.0	Pt	619	8.9	Pt	619	10.8	Pt	599	12.5	B	587	9.4	Ch	050953		
W PER			Y PER			W TAU			608	13.0	Br	598	9.4	Wy	587	10.7	Ch
024356			032043			042215			619	12.6	Pt	606	9.7	Wy	602	10.5	Wy
573	10.6	Ch	597	9.7	Ch	598	10.8	Wy	R DOR			610	9.6	Wy	606	10.6	Wy
600	10.4	Wy	598	9.6	Wy	606	10.6	Wy	*043562*			613	9.6	Wy	610	10.3	Wy
601	10.4	Sb	605	9.8	Wy	610	10.6	Wy	552	5.6	En	617	9.4	Lg	613	9.3	Gs
605	10.6	Wy	611	10.2	Wy	611	10.4	Jo	558	5.3	Bl	619	9.3	Pt	619	9.3	Pt
610	10.5	Wy	613	10.2	Wy	613	10.0	Gs	561	5.5	Ht	ε AUR			624	9.5	Al
613	10.4	Wy	619	10.0	Pt	613	10.5	Wy	562	5.2	Sm	045443			T PIC		
619	10.2	Pt	R PER			616	10.4	Gi	563	5.6	En	509	3.9	L	*051247*		
R HOR			032335			619	9.5	Pt	565	5.4	Bl	515	3.8	L	553[	13.1	Bl
025050			600	8.8	Wy	S TAU			567	5.2	Sm	520	3.9	L	561	13.1	Ht
553	12.6	En	611	8.7	Wy	042309			568	5.2	Ht	545	3.8	L	568	13.1	Ht
553	12.6	Bl	613	8.5	Gs	569	14.3	Nz	575	5.2	Bl	555	3.8	L	570	12.2	Sm
561	12.6	Ht	616	9.0	Kz	589	14.7	Bf	580	4.9	Dr	565	3.9	L	584	11.6	Dr

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J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
T PIC	S ORI	S CAM	SU TAU	α ORI	X AUR
051247	*052404*	053068	054319	054907	060450
587 11.3 Dr	613 11.1 Wy	588 9.0 Ch	610 10.5 L	608 0.2 L	597 9.2 Ch
591 10.9 Dr	619 10.8 Pt	602 9.4 Wy	611 10.5 L	611 0.5 L	599 9.4 Ch
595 10.5 Dr	T ORI	606 8.8 Wy	612 10.6 L	U ORI	610 10.4 B
599 10.3 Dr	*053005a*	611 8.8 Wy	612 10.7 Wy	054920a	618 10.2 Al
Nov TAU	582 10.8 L	613 8.8 Wy	613 10.7 Wy	586 7.0 Ah	619 11.4 Pt
051316	582 10.8 An	619 8.5 Pt	614 10.0 Lg	587 7.1 Ch	V AUR
585 13.3 L	585 10.7 L	RR TAU	614 10.3 Sf	588 7.3 Ah	061647
594 13.2 L	586 11.0 L	053326	614 10.0 Pt	590 7.4 Ah	585 11.6 L
609 13.2 L	586 10.2 An	566 13.6 Nz	617 9.6 Lg	598 7.6 Ah	594 11.6 L
T COL	587 10.2 An	574 13.5 Nz	618 9.5 Lg	601 7.7 Ah	596 11.3 B
051533	587 10.9 L	595 13.2 Bf	618 10.1 Sf	604 7.7 Ah	601 11.8 L
553 12.1 En	588 11.0 Wy	608 11.4 B	618 9.9 Pt	605 7.8 Ah	608 11.1 B
558 11.9 Bl	588 10.7 L	RU AUR	619 9.7 Pt	611 8.0 Ah	611 12.1 L
561 11.8 Ht	593 10.7 L	053337	620 9.8 Pt	611 7.7 Jo	617 11.8 Lg
562 12.6 Sm	594 10.9 L	617 13.7 Lg	S COL	613 8.5 Gs	V MON
565 12.0 Bl	595 10.5 L	U AUR	*054331*	616 8.3 Wd	*061702*
568 12.1 Ht	596 10.0 L	053531	553 9.6 En	619 7.8 Pt	589 8.5 Ch
575 12.1 Bl	597 10.1 L	588 12.3 Ch	558 9.2 Bl	620 8.0 Rw	618 9.7 Al
584 11.9 Dr	597 10.1 An	599 10.9 Sf	561 9.6 Ht	624 7.8 Al	619 9.8 Pt
591 11.8 Dr	598 10.0 L	614 9.3 Sf	562 8.8 Sm	V CAM	AG AUR
595 11.5 Dr	599 10.2 Wy	619 8.5 Pt	563 9.0 En	054974	062047
601 11.1 Dr	599 10.4 Pt	Y TAU	565 8.9 Bl	588 11.4 Ch	585 9.3 L
617 10.0 Lg	600 10.1 L	053920	567 8.4 Sm	599 11.1 Sf	594 9.3 L
S AUR	601 10.0 L	583 8.3 Kl	568 9.6 Ht	610 11.2 B	601 9.4 L
052034	601 10.6 Pt	SU TAU	575 9.2 Bl	614 11.6 Sf	608 9.4 L
586 11.9 An	601 9.9 Sp	054319	Z TAU	619 11.6 Pt	U LYN
588 11.2 Ch	603 10.0 Wy	582 13.3 L	054615a	Z AUR	063159
597 11.7 An	605 10.5 Pt	582 12.8 An	566 12.8 Nz	055353	596 10.5 B
598 11.1 Wy	608 10.2 L	585 13.2 L	595 11.7 Bf	588 10.0 Ch	R MON
608 11.2 Wy	608 10.2 B	586 13.3 L	599 11.2 Sf	591 10.3 Br	063308
611 11.0 Wy	609 10.2 Wy	586 12.4 An	614 10.1 Sf	599 10.0 Pt	588 11.8 Wy
613 11.0 Wy	610 10.1 L	587 12.4 An	618 10.0 Sf	601 10.2 Pt	613 11.7 Wy
619 9.9 Pt	611 10.2 L	587 12.6 L	RU TAU	603 10.3 Wy	617 11.2 Lg
620 11.1 Sp	612 11.1 L	588 12.4 L	054615c	604 10.0 Pt	619 11.0 Pt
W AUR	612 10.4 Wy	588 12.3 Wy	566 13.8 Nz	608 10.5 Br	NOV PIC
052036	613 11.0 Wy	591 12.4 L	595 14.7 Bf	608 10.0 B	*063462*
585 11.7 L	616 10.7 Gi	592 12.2 L	618 12.8 Sf	609 10.4 Wy	553 7.3 En
586 11.3 An	619 10.4 Pt	593 11.9 L	R COL	612 10.7 Wy	561 7.4 Ht
588 11.3 Ch	620 10.6 Pt	594 11.9 L	*054629*	612 10.6 Br	562 7.4 Sm
597 10.9 An	AN ORI	595 11.9 L	558 12.4 Bl	614 10.2 Pt	567 7.5 Sm
599 10.7 Sf	*053005t*	596 11.8 L	561 12.3 Ht	615 10.2 Pt	568 7.3 Ht
601 10.5 L	582 11.6 L	596 10.9 B	562 12.4 Sm	616 10.2 Pt	568 7.3 En
609 9.9 L	585 11.9 L	597 11.6 L	563 12.0 En	618 10.6 Pt	570 7.5 Sm
614 10.1 Sf	586 11.6 L	597 11.5 An	565 12.0 Bl	619 10.6 Pt	S LYN
616 10.1 Wn	587 11.8 L	598 11.7 L	567 12.0 Sm	620 10.6 Pt	063558
619 8.7 Pt	588 11.6 L	599 10.3 B	568 12.2 Ht	623 10.6 Pt	589 13.2 Ch
RR CAM	593 11.7 L	599 11.1 Sf	575 10.6 Bl	R OCT	599 13.8 Sf
052372	594 11.6 L	599 10.6 Pt	584 9.8 Dr	*055686*	614 13.6 Sf
591 9.6 Br	595 11.8 L	600 11.0 Wy	587 9.7 Dr	553 11.9 Bl	616 13.1 Gi
608 10.0 Br	596 11.8 L	600 11.3 L	591 9.5 Dr	560 12.0 En	X GEM
S ORI	597 11.8 L	601 11.3 L	595 9.2 Dr	562 11.9 Bl	064030
052404	598 11.7 L	601 10.8 Pt	601 9.6 Dr	565 12.0 Bl	582 8.6 Bn
586 11.2 An	600 11.6 L	603 10.9 Wy	α ORI	591 12.8 Dr	586 8.7 Bn
597 11.2 An	601 11.6 L	604 10.5 Pt	054907	601 12.6 Dr	589 9.7 Wy
602 11.3 Wy	608 11.6 L	608 10.5 L	585 0.4 L	X AUR	598 9.2 Bn
608 11.2 Wy	610 11.6 L	609 10.6 L	587 0.3 L	060450	601 10.5 Sp
608 10.3 B	611 11.6 L	609 10.7 Wy	594 0.2 L	588 9.0 Ch	602 10.3 Wy
611 11.1 Wy	612 11.6 L	610 10.4 Lg	597 0.7 An	594 9.1 Ch	609 10.6 Wy

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J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
X GEM	R CMI	S VOL	U CNC	R CAR	Z CAR
064030	070310	*073173*	083019	*092962*	*101058a*
612 10.7 Wy	608 9.4 B	561[12.8 Ht	620[13.5 Bw	590 7.0 Dr	565 10.7 Bl
620 11.7 Bw	617 9.5 Lg	568[13.2 Ht	X UMA	595 6.9 Dr	575 10 1 Bl
624 11.3 Bn	R VOL	584 13.7 Dr	083350	599 6.7 Dr	580 10.6 Dr
628 11.5 Bn	*070772*	590 13.6 Dr	588 12.9 Wy	601 6.7 Dr	586 10.9 Dr
W MON	561 11.3 Ht	595 13.4 Dr	613[13.4 Wy	X HYA	590 10.8 Dr
064707	561 12.0 En	601 13.3 Dr	S HYA	*093014*	595 11.0 Dr
619 9.9 Pt	562 11.8 Sm	U CMI	084803	556 11.4 Nz	AF CAR
Y MON	566 12.0 En	073508	589 10.7 Ch	566 12.0 Nz	*101058b*
065111	568 11.8 Ht	586 10.8 L	618 12.5 Pt	574 12.2 Nz	586 12.0 Dr
589 12.0 Ch	570 11.8 Sm	594 11.4 L	T HYA	589 12.6 Wy	590 12.3 Dr
610 11.1 B	584 12.5 Dr	608 11.4 L	*085008*	589 12.9 Ch	595 12.6 Dr
617 10.8 Lg	595 11.7 Dr	618 11.8 Pt	586 9.7 L	598 12.7 Bf	W VEL
619 10.5 Pt	601 12.5 Dr	S GEM	589 9.9 Ch	610 13.5 Bf	*101153*
X MON	L_2 PUP	073723	597 10.1 L	R LMI	562 12.6 Bl
065208	*071044*	589[13.6 Ch	608 10.6 L	093934	565 12.2 Bl
587 8.0 L	580 4.2 Dr	616 14.0 Gi	T CNC	589 12.2 Ch	575 11.9 Bl
588 8.5 Br	584 4.4 Dr	W PUP	085120	618 11.8 Pt	U HYA
589 8.1 Ch	586 4.3 Dr	*074241*	589 8.6 Ch	RR HYA	*103212*
591 8.6 Br	591 4.4 Dr	558 8.0 Bl	602 9.0 Wy	*094023*	575 6.0 Kd
596 8.0 L	595 4.5 Dr	561 8.5 En	612 8.8 Wy	586[13.5 Dr	585 4.9 L
608 8.1 L	599 4.5 Dr	565 7.9 Bl	618 8.0 Pt	595[13.6 Dr	588 4.9 L
R LYN	601 4.8 Dr	567 8.2 Sm	T PYX	R LEO	593 4.9 L
065355	RR MON	568 7.9 Ht	*090031*	094211	601 5.1 L
589 11.3 Ch	071201	575 8.0 Bl	562 [u Bl	589 8.2 Ch	608 4.9 L
V CMI	589[13.0 Ch	T GEM	V UMA	590 8.1 Ah	RZ CAR
070109	617 13.5 Lg	074323	090151	599 7.9 Pt	103270
583 10.6 Ch	V GEM	589[13.1 Ch	586 10.8 L	604 8.8 Ah	586[13.8 Dr
591 11.4 Ch	071713	611 13.3 Wy	593 10.9 L	620 9.6 Rw	601[13.9 Dr
614 12.1 Sf	616 9.4 Gi	613 13.4 Wy	608 11.0 L	Y HYA	R UMA
617 12.2 Lg	617 8.9 Lg	619 13.1 Bw	W CNC	*094622*	103769
R GEM	618 8.5 Pt	627 11.8 Bw	090425	599 6.3 Pt	589 12.5 Ch
070122a	S CMI	U PUP	585 14.0 L	Z VEL	599 12.5 Ch
585 7.5 Ch	072708	*075612*	593 14.3 L	*094953*	V HYA
590 7.5 Ah	583 7.0 Ch	594[12.9 Ch	RX UMA	558 12 2 Bl	*104620*
598 7.5 Ah	590 7.5 Wy	619 13.2 Bw	090567	586 12.8 Dr	562 7.8 Bl
599 7.3 Ch	591 7.2 Ch	R CNC	586 11.1 L	595 13.1 Dr	587 7.2 L
601 7.6 Ah	603 7.9 Wy	081112	593 11.2 L	V LEO	594 7.0 Ch
604 7.3 Ah	608 7.9 B	589 11.4 Ch	608 11.2 L	095421	597 7.4 L
605 7.4 Ah	609 8.1 Wy	618 10.7 Pt	RW CAR	589 12.6 Ch	599 6.8 Pt
611 7.6 Ah	611 8.1 Jo	V CNC	*091868*	599 12.5 Pt	607 7.2 L
611 7.7 Jo	612 7.5 Al	081617	558 10.4 Bl	RV CAR	RS HYA
616 8.0 Wd	612 8.1 Wy	589 9.5 Ch	565 11.5 Bl	*095563*	*104628*
618 7.0 Al	616 7.8 Al	591 9.9 Br	575 11.8 Bl	558[13.1 Bl	562[13.0 Bl
618 7.1 Pt	618 8.3 Pt	612 11.3 Br	584 12.1 Dr	S CAR	W LEO
625 7.0 Al	T CMI	RT HYA	590 12.7 Dr	*100661*	104814
Z GEM	072811	*082405*	601 13.0 Dr	558 7.1 Bl	566 13.6 Nz
070122b	601 10.7 Sp	593 8.4 L	Y VEL	565 8.4 Bl	574 13.6 Nz
618 12.5 Pt	617 10.6 Lg	608 8.4 L	*092551*	575 8.4 Bl	598 13.9 Bf
625 12.5 Al	618 11.0 Pt	618 8.8 Pt	558[12.9 Bl	580 9.2 Dr	S LEO
TW GEM	Z PUP	R CHA	586[13.1 Dr	584 9.5 Dr	110506
070122c	*072820b*	*082476*	R CAR	586 9.4 Dr	539 10.6 Ch
618 8.0 Pt	556[13.7 Nz	553 13.0 Bl	*092962*	590 9.3 Dr	599 11.6 Pt
R CMI	574[13.7 Nz	558 12.5 Bl	558 8.7 Bl	595 9.4 Dr	RY CAR
070310	598[13.7 Bf	565 12.3 Bl	565 8.6 Bl	599 9.3 Dr	*111561*
583 9.4 Ch	610[13.3 Bf	566 12.4 En	575 8.2 Bl	601 8.8 Dr	558[13.1 Bl
586 8.9 L	S VOL	567 12.4 Sm	580 7.2 Dr	Z CAR	586[13.3 Dr
594 9.6 L	*073173*	575 12.2 Bl	584 7.2 Dr	*101058a*	595[13.5 Dr
608 9.3 L	553 13.4 Bl		586 7.1 Dr	558 10.7 Bl	

VARIABLE STAR OBSERVATIONS RECEIVED DURING JANUARY, 1929.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
RS CEN	U CEN	S UMA	T CEN	R BOO	S UMI
111661	*122854*	123961	*133633*	143227	153378
558 9.7 Bl	562[12.4 Bl	604 8.2 Ah	595 5.8 Dr	587 11.0 Lj	595 9.3 Lj
565 10.0 Bl	T UMA	604 8.4 Kl	601 6.0 Dr	593 11.5 Ch	599 8.5 Pt
575 10.7 Bl	123160	605 8.1 Ah	RT CEN	595 11.7 Lj	602 9.4 Lj
580 11.4 Dr	579 8.2 Kl	609 8.4 Kl	*134236*	599 11.7 Pt	612 9.6 Lj
586 12.1 Dr	581 8.2 Kl	611 7.7 Ah	562 11.2 Bl	U BOO	T NOR
590 12.3 Dr	583 7.9 Kl	611 8.1 Lj	586 12.5 Dr	144918	*153654*
595 12.5 Dr	586 7.7 Kl	612 8.0 Lj	590 12.7 Dr	589 11.7 Wy	590[12.8 Dr
601 12.9 Dr	586 7.9 Ah	RU VIR	601 12.4 Dr	610 11.8 Wy	R CRB
X CEN	588 7.7 Ah	124204	R CVN	Y LUP	154428
114441	589 7.4 Kl	585 9.4 L	134440	*145254*	516 5.7 Km
562 10.9 Bl	590 7.3 Ah	594 10.4 L	594 11.4 Ch	558 12.2 Bl	521 6.0 Kd
580 8.4 Dr	593 6.9 Ch	599 9.7 Pt	599 11.5 Pt	586 13.2 Dr	528 5.8 Km
586 8.2 Dr	598 6.8 Ah	608 10.1 L	T APS	590 13.3 Dr	528 6.1 Kd
590 7.9 Dr	599 6.8 Pt	U VIR	*134677*	S APS	529 5.8 Km
595 7.5 Dr	601 6.8 Ah	124606	552[13.2 Bl	*145971*	538 5.8 Km
601 7.2 Dr	604 6.7 Ah	585 10.9 L	562[12.7 Sm	552[13.4 Bl	551 5.8 Km
W CEN	604 6.4 Kl	594 11.4 L	570 12.3 Sm	558[13.4 Bl	553 5.9 Km
115058	605 6.6 Ah	599 11.8 Pt	RU HYA	567[12.5 Sm	553 5.8 Kd
562 13.2 Bl	609 6.4 Kl	608 12.4 L	*140528*	570[11.9 Sm	555 5.9 Km
R COM	611 6.8 Ah	U OCT	586 9.0 Dr	RT LIB	562 5.6 Km
115919	R VIR	*131283*	590 9.1 Dr	*150018*	575 6.0 Kd
589[12.5 Wy	123307	558 9.2 Bl	601 9.6 Dr	599 9.0 Pt	585 6.0 L
594[12.5 Ch	599 10.4 Pt	560 9.4 En	R CEN	605 8.9 Wy	587 6.1 Lj
SU VIR	RV DRA	561 9.4 Ht	*140959*	610 8.9 Wy	588 6.1 Lj
120012	123366	562 9.9 Sm	558 10.3 Bl	T LIB	588 6.0 L
589 11.5 Wy	583 9.8 Br	565 9.4 Bl	565 10.4 Bl	*150519*	593 6.0 L
594 10.8 Ch	588 9.9 Br	566 9.7 En	586 10.1 Dr	610[11.5 Wy	593 6.1 Ch
599 10.1 Pt	589 9.9 Br	568 9.9 Ht	590 10.1 Dr	Y LIB	594 5.9 L
610 10.5 Wy	591 9.9 Br	570 9.9 Sm	601 9.8 Dr	*150605*	595 6.1 Lj
R CRV	608 10.3 Br	575 9.9 Bl	U UMI	587 9.8 L	599 6.2 Pt
121418	612 10.4 Br	587 10.4 Dr	141567	597 10.9 L	600 5.9 L
556 13.4 Nz	RS UMA	599 11.4 Dr	586 10.3 Ah	608 11.2 L	601 6.1 L
566 12.3 Nz	123459	W VIR	587 10.7 Lj	S LIB	601 6.0 Sp
574 11.7 Nz	556 9.4 Nz	*132002*	593 10.6 Ch	*151520*	604 6.2 Pt
587 11.2 L	566 9.9 Nz	589 9.5 Wy	595 11.0 Lj	599[10.4 Ch	606 6.0 L
597 10.6 L	574 11.0 Nz	R HYA	599 10.9 Pt	600 12.1 L	608 6.1 L
598 10.5 Bf	593 11.3 Ch	*132422*	612 11.4 Lj	608[11.0 L	609 6.0 L
599 10.2 Pt	598 11.9 Bf	575 5.6 Kd	612 10.9 Cl	S SER	611 6.0 L
607 9.8 L	599 11.6 Pt	587 5.3 L	S BOO	151714	611 6.1 Lj
610 9.3 Bf	610 12.6 Bf	593 5.6 Ch	141954	588 11.0 L	615 6.2 Pt
SS VIR	S UMA	597 5.6 L	587 12.5 L	597 11.7 L	618 6.2 Pt
122001	123961	599 6.2 Pt	593 13.1 Ch	609 11.8 L	623 6.1 Pt
587 7.4 L	579 8.8 Kl	608 6.3 L	597 13.0 L	S CRB	X CRB
597 7.3 L	581 8.8 Kl	S VIR	599 12.8 Pt	151731	154536
608 7.7 L	582 8.5 An	*132706*	609 12.9 L	593 6.7 Ch	599 9.2 Pt
T CVN	583 8.8 Kl	594 12.4 Ch	RS VIR	599 6.7 Pt	R SER
122532	586 8.8 Kl	599 12.0 Pt	142205	RS LIB	154615
594 9.9 Ch	586 8.5 Ah	RV CEN	587 8.0 L	*151822*	599 7.7 Pt
599 9.8 Pt	587 8.6 Lj	*133155*	**597 8.1 L**	601 7.4 L	V CRB
Y VIR	588 8.4 Ah	562 9.5 Bl	598 8.1 Bf	608 7.7 L	154639
122803	589 8.8 Kl	586 9.1 Dr	608 8.4 L	R NOR	353 8.3 Kd
556 11.8 Nz	590 8.3 Ah	590 9.0 Dr	610 8.4 Bf	*152849*	599 8.0 Pt
566 12.6 Nz	593 8.6 Ch	595 9.0 Dr	V BOO	586 12.4 Dr	RR LIB
574 12.8 Nz	595 8.7 Lj	T CEN	142539a	S UMI	*155018*
587 13.4 L	597 8.4 An	*133633*	521 8.5 Kd	153378	601[12.5 L
598 14.2 Bf	598 8.4 Ah	562 7.1 Bl	528 8.7 Kd	585 9.0 Lj	Z SCO
610 14.7 Bf	599 8.5 Pt	586 6.0 Dr	593 11.6 Ch	587 9.2 Lj	*160021*
	601 8.4 Ah	590 5.9 Dr	599 11.0 Pt	594 9.0 Ch	601[11.0 L

VARIABLE STAR OBSERVATIONS RECEIVED DURING JANUARY, 1929.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
Z Sco	R Dra	W Pav	SV Her	T CrA	RY Sgr
160021	163266	*174162*	182224	*185537b*	*191033*
609 11.1 L	604 7.5 Ah	552[13.0 Bl	594 9.7 Pt	552[13.0 Bl	584 7.0 Dr
U Ser	605 7.5 Ah	561[13.0 Ht	602 10.2 L	Z Lyr	585 6.8 L
160210	611 7.8 Ah	568[12.3 Ht	612 10.4 L	185634	594 6.5 Dr
590[12.0 Wy	611 7.8 Lj	U Ara	T Ser	585 11.8 L	TY Sgr
599 12.9 Pt	612 7.8 Lj	*174551*	182306	594 10.8 L	191124
605 11.4 Wy	TX Dra	560[12.3 En	594 12.5 Pt	602 10.7 L	552[13.0 Bl
610 11.2 Wy	163360	570[11.9 Sm	X Oph	609 10.2 L	S Sgr
SX Her	589 7.7 Br	V Dra	183308	RT Lyr	*191319a*
160325	591 7.7 Br	175654	583 7.9 Ch	185737	552[12.9 Bl
593 7.8 L	S Her	594 12.4 Pt	585 8.0 L	588[13.3 Ch	SW Sgr
599 7.8 Pt	164715	R Pav	594 8.1 L	V Aql	*191331*
604 8.0 Pt	599 9.2 Pt	*180363*	594 8.1 Pt	*185005*	552 12.9 Bl
607 7.9 L	610 9.4 Wy	561[12.3 Ht	607 8.6 L	583 7.8 Ch	558 12.9 Bl
608 8.0 L	RS Sco	568[12.3 Ht	RS Dra	R Aql	565 12.6 Bl
615 8.2 Pt	*164844*	584[12.9 Dr	184074	190108	574 12.4 Bl
618 8.2 Pt	554 7.5 Sm	595 12.9 Dr	588 10.7 Br	588 11.8 Ch	TZ Cyg
623 8.0 Pt	558 7.6 Bl	T Her	591 10.9 Br	594 11.1 Pt	191350
RU Her	560 8.0 En	180531	R Sct	RX Sgr	594 10.6 Pt
160625a	561 8.6 Ht	521 8.2 Kd	184205	*190818*	U Lyr
593 11.4 L	562 7.6 Sm	525 8.4 Kd	525 5.5 Kd	560 11.8 En	191637
599 11.5 Pt	563 8.2 En	529 8.5 Kd	528 5.7 Kd	RW Sgr	594 10.8 Pt
609 12.1 L	565 8.0 Bl	583 13.0 L	530 5.7 Kd	*190819a*	AF Cyg
R Sco	574 8.6 Bl	584 13.3 An	553 5.9 Kd	560 9.7 En	192745
161122a	RR Sco	592 13.8 L	562 6.1 Kd	566 9.7 En	583 7.3 Br
610[13.6 Bf	*165030a*	594 13.0 Pt	565 6.0 Kd	S Lyr	589 7.3 Br
S Sco	558 7.9 Bl	602 13.6 L	571 6.1 Kd	190925	591 7.2 Br
161122b	RV Her	612[12.4 L	573 6.0 Ch	585[14.5 L	608 7.1 Br
610 11.4 Bf	165631	W Dra	583 5.8 Ch	594[15.0 L	RT Aql
W CrB	552[13.0 Bl	180565	584 6.0 An	599[13.1 Wy	193311
161138	586[12.7 An	594 10.3 Pt	585 6.2 Kd	X Lyr	588 9.0 Ch
599 8.0 Pt	TT Dra	TV Her	586 5.9 An	190926	594 9.0 Pt
601 8.1 Sp	171157	181031	589 6.2 Lg	594 9.0 Pt	R Cyg
U Her	583 9.5 Br	583[13.5 L	590 6.0 Kd	RS Lyr	193449
162119	589 9.3 Br	594 14.3 L	591 5.7 L	190933a	586[13.1 Ch
581 8.5 Kl	591 9.3 Br	W Lyr	596 5.5 L	588[13.4 Ch	594 13.6 Pt
599 9.0 Pt	Z Oph	181136	597 6.0 An	RU Lyr	599[13.1 B
SS Her	171401	583 8.2 An	Nov Aql	190941	RV Aql
162807	611 9.5 Wy	594 7.7 Pt	184300	594 10.5 Pt	193509
593 9.6 L	RS Her	597 8.4 An	583 10.6 Ch	U Dra	594 9.9 Pt
599 10.2 Pt	171723	RU Dra	RX Lyr	190967	T Pav
609 10.6 L	604 8.0 Pt	181859	185032	588 10.8 Ch	*193072*
W Her	S Oct	583 9.6 Br	588[13.0 Ch	594 10.8 Pt	558 10.7 Bl
163137	*172486*	589 9.7 Br	S CrA	RY Sgr	560 11.0 En
599 13.8 Pt	552 12.6 Bl	591 9.8 Br	*185437a*	*191033*	561 11.2 Ht
R Dra	553 12.8 En	608 10.3 Br	552 12.5 Bl	528 6.3 Kd	562 11.0 Sm
163266	561 12.6 Ht	609 10.4 Br	558 11.8 Bl	530 6.3 Kd	565 11.4 Bl
585 7.3 Lj	568 13.0 Ht	RV Sgr	565 11.8 Bl	554 6.5 Sm	566 11.2 En
586 7.3 Ah	582 13.2 Dr	*182133*	574 12.0 Bl	557 6.8 En	568 11.7 Ht
587 7.2 Lj	595 13.8 Dr	558 10.7 Bl	ST Sgr	558 6.3 Bl	570 11.5 Sm
588 7.2 Lj	RU Sco	565 11.1 Bl	*185512a*	560 6.8 En	574 11.5 Bl
588 7.4 Ah	*173543*	574 11.7 Bl	585[13.5 L	561 6.5 Ht	582 11.8 Dr
590 7.3 Ah	558 9.2 Bl	584 11.5 Dr	R CrA	562 6.1 Sm	587 11.9 Dw
595 7.4 Lj	565 9.4 Bl	SV Her	*185537a*	565 6.0 Bl	595 12.6 Dr
598 7.6 Ah	574 9.8 Bl	182224	552 12.5 Bl	567 6.1 Sm	RT Cyg
599 7.3 Pt	SV Sco	583 9.6 L	558 11.8 Bl	568 6.5 Ht	194048
599 7.2 Ch	*174135*	585 9.4 L	565 12.1 Bl	570 6.1 Sm	586 7.4 Ah
601 7.4 Ah	558 11.4 Bl	586 9.6 An	574[12.5 Bl	574 6.0 Bl	586 6.9 Ch
602 7.5 Lj	565 11.9 Bl	594 9.6 L		582 6.9 Dr	587 7.5 Ah

VARIABLE STAR OBSERVATIONS RECEIVED DURING JANUARY, 1929.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
RT CYG	S TEL	RS CYG	U CYG	T DEL	X CAP
194048	*195855*	200938	201647	204016	*210221*
588 7.7 Ah	552 13.1 Bl	579 7.1 Ch	608 9.8 B	586[13.3 Ch	553[12.7 Bl
591 7.2 Ch	563[12.6 En	580 7.2 Ch	U MIC	596 13.6 B	X CEP
599 7.6 B	SY AQL	583 7.2 Ch	*202240*	597[13.3 An	210392
601 7.9 Sb	200212	586 7.2 Ch	558 11.7 Bl	609 13.5 B	596 10.0 B
601 8.2 Ah	587 8.6 L	588 7.2 L	565 12.3 Bl	V AQR	RS AQR
602 8.2 Ah	587 8.8 An	590 7.2 Ch	582 12.6 Dr	204102	*210504*
604 8.2 Ah	594 8.6 L	591 7.2 Ch	587 12.8 Dw	583 9.8 Ch	588 12.0 L
605 8.2 Ah	594 8.6 Pt	594 7.4 L	591 13.2 Dr	594 9.2 Pt	594 11.6 L
611 8.2 Jo	600 8.7 Wy	594 7.0 Pt	RW CYG	W AQR	607 11.1 L
611 8.5 Ah	602 8.9 L	597 7.2 Ch	202539	*204104*	Z CAP
615 8.9 Sb	609 9.1 L	602 7.3 L	582 9.4 An	552 13.1 Nz	*210516*
TU CYG	609 8.8 Wy	607 7.3 L	597 9.1 An	557 13.4 Nz	552 13.9 Nz
194348	BU CYG	611 7.3 Jo	605 9.4 An	579 13.9 Nz	557 14.2 Nz
586[12.4 Ch	200250	615 7.4 Sb	RU CAP	587 14.2 Bf	587 14.4 Bf
599 12.3 B	585[12.5 Lj	622 7.7 Sb	*202622*	588 13.9 L	R EQU
X AQL	612 12.5 Lj	628 7.8 Sb	552 14.7 Nz	594 13.9 L	210812
194604	S CYG	R DEL	557 15.0 Nz	612 14.2 L	552 12.0 Nz
594 9.5 Pt	200357	201008	564[14.5 Nz	U CAP	557 12.5 Nz
χ CYG	586[13.2 Ch	583 10.6 Ch	579[14.7 Nz	*204215*	587 14.2 Bf
194632	R CAP	584 10.9 An	587[14.7 Bf	565 13.1 Bl	595 14.5 Bf
582 13.0 An	*200514*	588 10.7 L	Z DEL	V DEL	596 13.9 B
586[13.4 Ch	583 9.4 Ch	594 10.8 L	202817	204318	603 14.6 Bf
594 12.5 Pt	S AQL	594 11.2 Pt	594 9.2 Pt	617 13.5 Lg	612 15.1 Bf
597 13.3 An	200715a	597 11.4 An	ST CYG	618 13.4 Lg	T CEP
S PAV	583 11.0 Br	600 11.4 Wy	202954	T AQR	210868
194659	583 10.7 Ch	602 11.2 L	594 13.8 Pt	*204405*	579 6.6 Ch
552 8.7 En	589 11.3 Br	609 11.8 L	609[12.6 Wy	583 9.5 Ch	586 6.6 Ah
563 9.0 En	591 11.2 Br	609 11.5 Wy	V VUL	594 9.1 Pt	586 6.7 Ch
582 8.6 Dr	594 11.4 Pt	613 12.0 Wy	203226	602 8.7 Sb	588 6.7 Ah
587 8.5 Dw	597 11.4 An	RT CAP	594 8.6 Pt	611 8.1 Sb	590 6.7 Ah
591 8.5 Dr	608 11.4 Br	*201121*	R MIC	615 8.0 Sb	594 6.5 Pt
RR SGR	RW AQL	528 7.6 Kd	*203429*	RZ CYG	596 7.4 Ch
194929	200715b	553 7.7 Kd	558 9.6 Bl	204846	601 7.0 Ah
558 12.4 Bl	594 9.1 Pt	SV CYG	565 9.4 Bl	594 13.1 Pt	605 7.0 Ah
582 13.0 Dr	R TEL	201130	575 9.0 Bl	608 12.6 B	605 6.9 Ah
RU SGR	*200747*	594 8.9 Pt	S DEL	S IND	610 8.0 Sb
195142	558 9.3 Bl	RT SGR	203816	*204954*	611 7.0 Jo
554 8.5 Sm	565 9.1 Bl	*201139*	585 9.8 Lj	553[13.5 Bl	611 7.4 Ah
558 8.4 Bl	575 9.0 Bl	558 8.1 Bl	588 9.5 Lj	S DEL	615 7.9 Sb
560 8.3 En	RU AQL	565 7.3 Bl	594 9.0 Pt	205017	616 8.2 Wd
561 8.5 Ht	200812	575 7.0 Bl	597 9.4 Lj	594 13.5 Pt	622 8.3 Sb
562 8.2 Sm	587 13.6 L	580 7.2 Dr	602 9.5 Lj	RR CAP	X PEG
565 8.0 Bl	594 13.9 L	582 7.1 Dr	612 9.5 Lj	*205627*	211614
567 8.2 Sm	602 13.8 L	584 7.2 Dr	V CYG	582 13.1 Dr	594 10.6 Pt
568 8.1 Ht	609[13.2 L	587 7.1 Dw	203847	587 12.5 Dw	596 10.5 B
574 7.8 Bl	W CAP	591 7.1 Dr	586 12.4 Ch	591 13.2 Dr	T CAP
RR AQL	*200822*	WX CYG	594 12.8 Pt	R VUL	*211615*
195202	558 11.8 Bl	201437b	609 12.4 B	205923a	558 11.5 Bl
594 11.5 Pt	565 12.1 Bl	583 11.2 Ch	Y AQR	594 12.6 Pt	565 11.6 Bl
NOV CYG	575 11.7 Bl	588 10.9 L	*203905*	596 12.0 Ch	575 12.1 Ch
195553	Z AQL	594 10.9 L	552 10.1 Nz	600 11.1 Wy	575 12.1 Bl
614[12.2 Pt	*200906*	594 11.0 Pt	557 10.1 Nz	609 9.4 Wy	S MIC
618[12.2 Pt	552 13.8 Nz	607 11.1 L	579 10.7 Nz	611 9.7 Jo	*212030*
Z CYG	557 14.0 Nz	608 10.5 B	583 11.0 Ch	V CAP	553[13.4 Bl
195849	564 14.4 Nz	U CYG	587 11.1 Bf	*210124*	567[12.4 Sm
586 8.8 Ch	579 13.7 Nz	201647	594 10.6 Pt	558 12.5 Bl	584 13.4 Dr
591 9.0 Ch	587 13.0 Bf	586 10.8 Ch	601 11.7 Sb	582[12.8 Dr	587 13.0 Dw
		594 9.8 Pt		591 12.7 Dr	

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J.D.Est.Obs.

S MIC
212030
591 13.0 Dr
Y CAP
212814
553[12.9 Bl
587[12.6 Ch
W CYG
213244
525 6.6 Kd
528 6.6 Kd
536 6.7 Kd
539 6.6 Kd
553 6.6 Kd
562 6.5 Kd
565 6.6 Kd
571 6.6 Kd
582 6.6 Kd
584 6.6 Kd
586 6.6 Kd
586 5.6 L
592 5.5 L
597 5.5 L
602 5.4 L
608 5.4 L
611 5.4 L
S CEP
213678
594 9.5 Pt
611 9.6 Jo
RU CYG
213753
583 8.5 Ch
594 8.5 Pt
598 8.6 Wy
609 8.6 Wy
613 9.0 Wy
619 9.1 Bw
RV CYG
213937
586 6.8 L
592 6.7 L
594 6.2 Pt
594 6.8 L
602 6.8 L
608 6.7 L
RR PEG
214024
594 13.8 Pt
610 13.6 B
R GRU
214247
553[13.7 Bl
554[12.9 Sm

J.D.Est.Obs.

R GRU
214247
561[12.9 Ht
567[12.9 Sm
582[14.3 Dw
V PEG
215605
594 13.0 Pt
U AQR
215717
594 11.0 Pt
RT PEG
215934
586 11.3 Ch
594 11.6 Pt
608 11.7 B
RZ PEG
220133b
585 9.8 Br
591 9.9 Br
594 9.1 Pt
608 10.0 Br
612 10.1 Br
T PEG
220412
585 14.2 L
586[12.7 Ch
594 14.2 L
608 13.0 L
Y PEG
220613
552 14.3 Nz
556 14.5 Nz
579[14.8 Nz
589 15.0 Bf
595 15.0 Bf
603[14.4 Bf
609[13.3 B
612 14.2 Bf
RS PEG
220714
552 14.3 Nz
556 14.4 Nz
579 14.0 Nz
589 14.6 Bf
595 14.4 Bf
596 13.4 B
603 14.4 Bf
609 12.3 B
612 14.4 Bf
UW PEG
221302
589 9.5 Br
591 9.5 Br
608 9.5 Br

J.D.Est.Obs.

TX PEG
221313
589 9.0 Br
591 9.0 Br
608 9.1 Br
X AQR
221321
552 10.0 Nz
557 10.1 Nz
579 11.4 Nz
587 11.4 Bf
612 13.4 Bf
T GRU
221938
552 8.2 En
561 8.2 En
562 8.2 Sm
567 8.4 Sm
S GRU
221948
562[12.8 Sm
568[12.8 Ht
582[14.5 Dw
RV PEG
222129
620 9.7 Sp
S LAC
222439
585 8.5 L
586 8.4 Ch
594 7.7 L
594 7.5 Pt
607 7.6 L
R IND
222867
558 8.6 Bl
565 8.6 Bl
575 8.3 Bl
580 8.6 Dr
584 8.9 Dr
586 8.7 Dw
591 9.0 Dr
595 9.2 Dr
599 9.5 Dr
T TUC
223462
561 13.0 Ht
561 12.8 En
567 12.6 Sm
568 12.8 Ht
580 12.3 Dr
582 12.4 Dr
586 12.4 Dw
591 11.5 Dr

J.D.Est.Obs.

T TUC
223462
595 11.2 Dr
599 10.9 Dr
R LAC
223841
585 10.0 L
586 9.9 Ch
594 9.5 L
594 9.7 Pt
607 9.6 L
RW PEG
225914
552 13.9 Nz
556 14.3 Nz
579 14.3 Nz
589 14.5 Bf
595 14.6 Bf
603 14.3 Bf
610 13.5 B
612 13.9 Bf
R PEG
230110
560 12.0 Wy
586 12.8 Ch
594 12.6 Pt
599 12.8 Sf
611 13.0 Sf
611 13.1 Wy
618 13.3 Lg
V CAS
230759
586 7.5 Ch
588 7.6 Ah
590 7.6 Ah
594 7.6 Pt
601 7.6 Ah
604 7.7 Ah
605 7.7 Ah
608 8.2 B
611 8.0 Ah
W PEG
231425
581 10.3 Wy
600 11.5 Wy
608 11.8 Wy
611 12.0 Wy
613 12.0 Wy
626 12.2 Gi
S PEG
231508
561 12.6 Wy
587 12.9 Wy
594 13.0 Pt
612[12.9 Wy

J.D.Est.Obs.

RY CEP
231878
590 9.5 Ch
V PHE
232746
561[13.2 Ht
567[13.2 Sm
582 13.1 Dw
582 13.0 Dr
586 12.9 Dw
591 13.0 Dr
595 12.5 Dr
599 12.5 Dr
Z AND
232848
590 9.8 Ch
594 9.6 Pt
618 9.9 Bw
ST AND
233335
581 11.2 Wy
590 11.5 Ch
594 11.1 Pt
598 11.3 Wy
608 11.5 Wy
612 11.3 Wy
613 11.3 Wy
617 11.1 Lg
R AQR
233815
528 8.7 Kd
552 8.9 En
553 8.8 Kd
558 8.9 Bl
561 9.0 Ht
562 8.8 Kd
563 8.8 En
565 9.0 Bl
567 9.0 Sm
568 9.1 Ht
575 9.0 Bl
583 8.9 Ch
585 9.0 L
591 8.5 Ch
594 8.9 L
594 8.5 Pt
607 8.8 L
617 8.4 Lg
618 8.3 Lg
620 8.8 Sp

J.D.Est.Obs.

Z CAS
233956
610 13.3 B
626 13.4 Gi
RR CAS
235053
598 13.2 Bn
599 12.8 B
610 13.3 B
R PHE
235150
582 13.3 Dr
586 13.3 Dw
591 13.4 Dr
595 13.6 Dr
V CET
235209
558 13.0 Bl
585 14.4 L
594 14.2 L
608[13.9 L
R TUC
235265
561[12.9 En
570[12.9 Sm
R CAS
235350
587 7.3 Ah
588 7.3 Ah
590 7.0 Ah
590 7.0 Ch
598 7.2 Ah
601 7.6 Ah
604 7.6 Ah
605 7.7 Ah
609 7.4 B
611 7.7 Ah
Z PEG
235525
594 12.9 Pt
W PEG
235715
618 9.1 Lg
Y CAS
235855
599 10.4 B
609 10.3 B
SV AND
235939
594 12.3 Pt
618 12.7 Bw

RAPIDLY VARYING IRREGULAR VARIABLES.

Star	J.D.	Est.Obs	J.D.	Est.Obs.
005840 RX ANDROMEDAE—				
	5601.7	11.4 Pt	5619.6	13.0 Pt
	5614.6	11.5 Pt		
010884 RU CEPHEI—				
	5587.6	8.7 L	5601.3	8.7 L
	5591.2	8.7 L	5606.6	8.8 L
	5596.2	8.8 L	5611.3	8.8 L
060547 SS AURIGAE—				
	5556.4	15.0 Nz	5603.1	[14.5 Bf
	5566.4	11.0 Nz	5604.6	[12.6 Pt
	5569.2	11.4 Nz	5606.7	12.8 L
	5573.3	[12.4 Ch	5607.6	12.4 L
	5574.4	14.2 Nz	5608.2	12.0 L
	5585.2	14.5 L	5608.3	12.0 L
	5585.4	14.7 L	5608.6	12.1 L
	5586.4	14.7 L	5609.2	11.9 L
	5587.3	14.8 L	5609.7	12.2 L
	5587.6	14.8 L	5610.3	12.1 L
	5588.4	14.8 L	5610.4	12.7 Bf
	5589.2	14.2 Bf	5610.8	12.8 Lg
	5591.2	13.3 L	5611.2	12.5 L
	5591.3	13.6 L	5611.7	12.8 L
	5592.2	[13.9 L	5612.1	13.2 Bf
	5593.4	14.7 L	5612.2	13.4 L
	5594.4	14.2 L	5612.6	[13.6 Wy
	5594.6	14.2 L	5613.6	[13.3 Wy
	5595.2	14.7 Bf	5614.8	13.7 Lg
	5595.3	14.1 L	5615.9	[11.0 Pt
	5596.3	14.5 L	5616.6	11.4 Gi
	5596.6	14.0 B	5617.8	12.6 Lg
	5597.3	[13.9 L	5618.5	13.1 Sf
	5598.3	14.5 L	5618.7	12.3 Lg
	5598.4	14.8 B	5618.9	12.3 Pt
	5599.6	[13.4 B	5619.6	13.4 Pt
	5600.4	14.7 L	5620.8	[12.6 Pt
	5601.3	14.5 L	5623.9	[12.4 Pt
	5601.7	14.5 L	5624.5	[12.4 Cl
	5602.3	[13.3 L		
074922 U GEMINORUM—				
	5556.4	13.6 Nz	5600.4	13.9 L
	5566.4	14.1 Nz	5601.4	[13.7 L
	5574.4	14.1 Nz	5603.6	[12.3 Wy
	5583.2	[12.3 Ch	5604.9	[12.4 Pt
	5585.6	13.9 L	5609.7	[12.4 L
	5586.7	14.0 L	5610.6	[13.5 B
	5588.4	14.2 L	5611.3	13.5 L
	5589.2	[13.7 Ch	5612.2	13.4 Bf
	5593.4	13.9 L	5612.6	13.7 Wy
	5594.6	13.8 L	5613.6	13.6 Wy
	5595.2	13.5 Bf	5615.9	[11.2 Pt
	5596.2	14.0 Ch	5617.8	13.5 Lg
	5597.1	[13.3 Ch	5618.9	[12.3 Pt
	5598.4	13.6 L	5619.6	[12.4 Pt
	5598.5	13.6 Bf	5620.8	[12.4 Pt
	5599.9	[12.4 Pt		
081473 Z CAMELOPARDALIS—				
	5582.4	12.7 L	5586.3	12.9 L
	5585.2	13.1 L	5586.3	11.9 An
	5585.7	12.8 L	5587.3	11.3 An
081473 Z CAMELOPARDALIS—				
	5587.3	11.9 L	5600.4	13.0 L
	5587.6	11.0 L	5601.3	13.0 L
	5588.2	10.8 L	5601.7	12.5 L
	5588.7	11.0 L	5602.2	12.9 L
	5590.2	10.8 Ch	5606.6	12.3 L
	5591.2	11.0 L	5607.2	11.4 L
	5593.4	12.1 L	5608.2	10.6 L
	5593.7	12.0 L	5608.6	11.0 L
	5594.4	12.3 L	5609.2	10.6 L
	5594.6	12.2 L	5609.7	10.8 L
	5595.2	12.8 L	5610.4	11.0 L
	5596.2	12.8 L	5610.7	11.0 L
	5597.3	12.7 L	5611.3	11.2 L
	5597.3	12.9 An	5612.2	11.3 L
	5598.2	12.8 L		
094512 X LEONIS—				
	5585.6	[14.0 L	5596.6	[14.2 L
	5586.7	[13.8 L	5597.6	[13.8 L
	5587.6	[14.7 L	5600.7	[14.7 L
	5588.7	[14.2 L	5601.7	[14.7 L
	5591.6	13.3 L	5606.7	[13.9 L
	5593.7	12.6 L	5607.6	[12.3 L
	5594.6	13.4 L		
202946 SZ CYGNI—				
	5601.7	9.0 Pt	5615.9	9.0 Pt
	5604.6	9.2 Pt	5616.6	9.0 Pt
	5605.7	9.5 Pt	5618.9	9.4 Pt
	5606.6	9.6 Pt	5619.6	9.1 Pt
	5614.6	8.7 Pt	5623.9	9.4 Pt
213843 SS CYGNI—				
	5573.1	9.5 Ch	5596.2	11.7 L
	5576.1	8.3 Ch	5597.1	11.8 Ch
	5579.0	8.5 Ch	5597.3	11.7 An
	5582.3	8.4 An	5597.3	11.7 L
	5582.4	9.0 L	5597.3	11.9 Lj
	5583.2	8.9 L	5598.2	11.8 L
	5584.2	8.5 An	5599.5	11.6 B
	5585.2	9.0 L	5599.5	11.8 Sf
	5585.3	9.0 Lj	5600.4	12.0 L
	5586.1	9.2 Ch	5601.3	11.9 L
	5586.2	9.6 An	5601.7	11.7 Pt
	5586.3	9.4 L	5602.2	11.9 Lj
	5586.3	9.4 Ah	5602.2	12.2 L
	5587.1	9.4 Ch	5604.6	11.7 Pt
	5587.2	9.6 L	5605.2	11.6 An
	5587.2	9.6 Ah	5605.7	11.7 Pt
	5587.3	9.7 An	5606.7	11.7 Pt
	5588.2	9.7 Ch	5608.2	12.1 L
	5588.3	9.9 L	5608.5	11.9 B
	5588.3	10.2 Lj	5610.8	11.6 Lg
	5588.4	10.2 Ah	5611.3	12.2 L
	5590.5	10.9 Ah	5611.3	11.8 Ah
	5591.2	11.0 L	5611.5	12.1 Sf
	5592.2	11.2 L	5612.2	12.1 Lj
	5594.1	11.6 Ch	5612.2	12.2 L
	5594.2	11.5 L	5612.5	12.0 Cl
	5595.2	11.6 L	5614.5	12.0 Sf
	5596.1	11.6 Ch	5614.6	11.7 Pt

RAPIDLY VARYING IRREGULAR VARIABLES.

Star	J.D.	Est.Obs	J.D.	Est.Obs.	Star	J.D.	Est.Obs.	J.D.	Est.Obs.
213843	SS CYGNI—				213843	SS CYGNI—			
	5614.8	11.8 Lg	5617.8	11.8 Lg		5618.7	11.7 Lg	5620.5	11.7 Sp
	5616.5	11.9 Sf	5618.5	11.8 Sf		5619.6	11.6 Pt	5620.5	11.8 Sf
	5616.6	11.7 Pt							

SUMMARY FOR MONTH OF JANUARY, 1929.

Observer	Initial	Vars.	Observations	Observer	Initial	Vars.	Observations
Ahnert	Ah	16	92	Kanamori	Km	1	8
Allen	Al	10	13	Kanda	Kd	15	68
Ancarani	An	22	47	Kohl	Kl	4	16
Baldwin	Bl	81	176	Kurtz	Kz	2	2
Bappu	Bf	32	71	Lacchini	L	76	389
Beyer	Br	19	59	Leiner	Lj	9	36
Bigelow	Bw	16	18	Logan	Lg	29	42
Boutell	BL	1	9	Peltier	Pt	165	219
Bouton	B	43	52	Rowley	Rw	2	2
Brown	Bn	3	9	Smith, F.W.	Sf	21	44
Chandra	Ch	121	170	Smith, W. H.	Sm	35	59
Clement	Cl	4	4	Soberanes	Sb	12	24
Dartayet	Dr	59	198	Spears	Sp	8	8
Dawson	Dw	16	17	Waterfield	Wf	1	5
Ensor	En	33	54	Webb	Wd	4	4
Gaebler	Gb	2	2	Whitney	Wy	49	142
Goodsell	Gs	5	5	Wilson	Wn	2	2
Guiler	Gi	8	8	Nizamiah Ob.	Nz	30	73
Houghton	Ht	26	48				
Jones	Jo	12	12	Totals	38	400	2207

variable went through three distinct, but irregular, maxima during the interval usually occupied in going from one maximum to the next. More observations from distant observers with large instruments will doubtless throw more light on this interesting star. The recent actions of this star remind one of the peculiar light variations which SS Cygni experienced some twenty years ago.

In view of the recent researches on R Scuti by Drs. Gerasimovič of Harvard and Alter of Michigan, it behooves observers to secure estimates on this star frequently and with extreme care. The increasing period indicated by Gerasimovič, and the two separate periods found by Alter, put this star in a class requiring our closest attention. Our records of the past years had much to do with the detection of these interesting facts concerning period.

February 7, 1929. LEON CAMPBELL, Recording Secretary.

COMET NOTES.

By G. VAN BIESBROECK.

COMET 1929 *a* (SCHWASSMANN-WACHMANN) has been frequently observed both visually and photographically during the month following the discovery. Further positions have been secured on various plates exposed before the object was found by the Hamburg astronomers. The first photographic record is still the one mentioned last month under date December 19 at the Harvard College Observatory.

The most recent measure obtained by the writer, on a plate exposed for two minutes in full moon with the 24-inch reflector, gives the position:

1929 Feb. 22.08310 $5^h\,47^m\,53^s.67$ $+22°\,11'\,43''.8$.

When compared with the ephemeris published on p. 110 the residual, observation minus computation, is found to be:

in α -33^s in δ $-2''.0$.

This relatively small deviation after one month's interval shows that the first orbit published last month is already a fair approximation. Since then another set of elements has been computed by Ch. H. Smiley (Period 15.87 years) but this orbit deviates more rapidly from the observations. On the other hand, *Circular* 220 of the Central Bureau of the Astronomical Union in Copenhagen brings the results of a more careful computation by A. C. D. Crommelin, based on the positions measured on the early Harvard plates. His elements are:

T = 1929 March 23.6552 U.T.
ω = 357° 57′ 6″.6
Ω = 126 7 14.4 } 1929.0
i = 3 43 16.8
e = 0.396787 (ϕ = 23° 22′ 39″.0)
q = 2.08523
Period = 6.42714 years

From these we have computed the following ephemeris:

EPHEMERIS FOR COMET 1929 *a*.

1929 0^h U.T.	α h m s	δ ° ′	Log. Δ	Log. r	Mag.
March 1	5 54 23	+22 30.0	0.191	0.330	12.5
5	5 58 43	39.7			
9	6 3 28	48.5	0.212	0.320	12.6
13	8 38	22 56.1			
17	14 11	23 2.6	0.233	0.319	12.7
21	20 5	7.8			
25	26 18	11.7	0.254	0.319	12.8
29	32 49	14.1			
April 2	39 35	15.0	0.274	0.319	12.9
6	6 46 36	+23 14.2			

The brightness is assumed at $12^M.5$ on March 1 but will probably be somewhat fainter.

The ephemeris will be found to represent the observations very closely. This more accurate orbit differs so little from our first determination that the change in Fig. 1 (p. 111) which represents the geometrical relations of the comet and the earth would hardly be noticeable.

The ephemeris shows that the slowly fading comet will stay closely to the ecliptic in the constellation of Gemini during the month of March and that it will gradually shift into the western sky. The comet has shown so far very little activity from the physical point of view. According to *Announcement Card* 86 of the Harvard College Observatory, Professor Perrine observing the comet on February 2 and 3 at Cordoba (Argentina) estimated the length of the tail as five degrees! There has been, probably, some error in transmitting this indication by cable; on January 20 the writer could not follow the tail over much more than a minute on a plate exposed with the 24-inch reflector.

The orbit of this comet does not seem to indicate kinship with any previous apparition. How different from Comet Forbes, found at the end of last year and

soon recognized as the return of a comet seen already several times previously!

No further recent observations of this comet have been published. It is probably too faint now for the southern observers.

The two comets 1927 *d* (STEARNS) and 1927 *i* (SCHWASSMANN-WACHMANN) are approaching the limit of reach of even the larger telescopes. No recent observations were secured here on account of unfavorable weather conditions.

Williams Bay, Wisconsin, February 25, 1929.

METEOR NOTES.

By CHARLES P. OLIVIER.

ANNUAL REPORT OF THE AMERICAN METEOR SOCIETY FOR 1928.

In 1928 the American Meteor Society had the best year of its existence. While unable to show a grand total of observations as large as for 1916, yet more important problems were undertaken and work of greater interest carried out. While praiseworthy work was done by many members, the large Texas group, working together in a concerted scientific attempt to help solve several important problems, deserves the highest praise for their combined results. The writer sincerely wishes similar groups could be formed elsewhere who would emulate their excellent example. For observers working alone, R. A. McIntosh of New Zealand has sent in the most important results, doubly so as coming from the Southern Hemisphere. In a letter R. M. Dole writes that he observed about 1200

TABLE I.

Observer	Station	Nights	Meteors	Remarks
Anyzeski, V.	New Haven, Conn.	11	279	
Brown, R.	Ft. Worth, Texas	3	45	
Bubar, D. C.	Decatur, Texas	2	76	Plotted 36
Bunch, S.	Ft. Worth, Texas	19	462	Plotted 427
Bunch, Mrs. S.	Ft. Worth, Texas	2	31	Plotted 14
Chesley, J. T.	Hamilton, Texas	1	8	
Conboy, J. J.	Lawton, Okla.	3	68	
Edwards, Mrs. W. H.	Fairhope, Ala.	1	43	Counts
Ford, C. B.	Ann Arbor, Mich.	4	111	
Klapperich, A.	Wilmette, Ill.		4	
Laurence, E. E.	S.S. "Olna"		13	Fireballs
Lawrence, A. S.	Long Island, N. Y.	2	11	
Logan, J. S.	Dallas, Texas		422	
McIntosh, R. A.	Auckland, N. Z.	37	639	
Monnig, O. E.	Ft. Worth, Texas	19	492	Plotted 366
Ninenger, H. H.	McPherson, Kansas	3	206	Counts
Olivier, C. P.	Flower Obs.,Pa.	6	142	
Pegues, C. M.	Urbana, Ill.	2	48	
Roach,	Ft. Worth, Texas	1	113	Counts
Sanders, B.	Ft. Worth, Texas	7	176	
Shinkfield, R. C.	Adelaide, S. Australia	2	3	
Thomsen, I. L.	Danneviske, N. Z.	8	125	
Watkins, G.	Caldwell, Idaho	1	12	
Whitney, B. S.	Lawton, Okla.	2	110	
U. S. Weather Bureau			66	Mostly fireballs
Hydrographic Office, U.S.N.			59	
Miscellaneous			30	
Total			3794	

Persons Not Members				
Burchard, Mr. and Mrs.	Fresno Co., Calif.	1	47	1 assistant
Burst, Capt. W. R.	S.S. "Golden Tide"	1	31	
McClees, J. W.	Bridgeport, Conn.	3	40	
McGirk, Lon, Jr.	El Monte, Calif.	1	33	
Higgs, C. D.	Yerkes Obs., Wis.	1	109	2 assistants
Stebbins, Dr. Joel	Washburn Obs., Wis.	1	111	5 assistants
Stratton, Prof. R.	Stillwater, Okla.	1	40	1 assistant
			411	Mostly counts
Total for all			4205	

meteors last year, but until the maps and blanks arrive here his observations cannot be added to the year's total—a policy to be rigidly adhered to from now on for every one. Table I gives the approximate number of nights each member observed and number of the meteors recorded.

In addition to the "Meteor Notes," ten in number, the writer published in the February, 1928, POPULAR ASTRONOMY an article entitled "Fireball of February 27, 1927." He also prepared the preliminary and final report of the Meteor Commission of the International Astronomical Union, of which he was re-elected chairman at the Leiden meeting last July. These will appear in the *Transactions of the I.A.U.* The final results of the work of the A.M.S., for 1919 to 1925 inclusive, is now in press and will appear in *Publications of the Leander McCormick Observatory,* University of Virginia, which was our headquarters from 1914 to 1928. The important work of Dr. W. J. Fisher of Harvard College Observatory has already been reviewed in the annual report of that observatory which appeared in the February number of POPULAR ASTRONOMY.

Thanks largely to the Hydrographic Office, U. S. Navy, and to the Marine Division, U. S. Weather Bureau, reports of 169 bright meteors or fireballs were received, most of them from ships at sea. Special mention should be made of our member, Third Officer E. E. Laurence of the British S.S. *Olna,* who contributed 13 of the above. The completeness of his records make them specially valuable. Duplicate observations from which heights should be derivable were received for several of these fireballs. This feature is yearly growing in importance, and the splendid coöperation of the Hydrographic Office and the Weather Bureau deserves special mention and sincere appreciation on our part.

TELESCOPIC METEORS.

Despite urgent requests to all observers, especially to those who work with small or medium telescopes and low powers, it has so far been impossible to enlist the coöperation of any large number in recording telescopic meteors. As the trouble involved is almost nothing, and blanks with instructions are gladly furnished upon request, the only explanation is that most observers erroneously see no use in making such records. They can, however, be assured that observations of telescopic meteors are most useful in a number of ways, and invaluable in the discussion of certain problems. If we could only get the majority of observers in America to report all such meteors that appear in their telescopes for the next two or three years, we would make great strides in this little known field. As an example of how few telescopic meteors are seen when high powers are used on large telescopes, the writer used the 26-inch McCormick and the 18-inch Flower telescopes on double stars during parts of 41 nights last year. He also used the 26-inch during five months on stellar parallax. Yet he saw just one telescopic meteor in 1928! Therefore it is to persons using telescopes with large

fields that we must turn for these data. Members of the A.A.V.S.O. are particularly urged to coöperate. We are already under obligations to several of them who were good enough to report for 1928, and to others for reports in previous years. The 1928 report is found in Table II.

TABLE II.

Chandra, R. G.	Jessore, India	4
Ford, C. B.	Ann Arbor, Mich	4
Logan, J. S.	Dallas, Texas	10
Monnig, O. E.	Ft. Worth, Texas	1
Olivier, C. P.	Flower Obs., Pa.	1
Peltier, L. C.	Delphos, Ohio	26
Smith, F. W.	Swarthmore, Pa.	15
Watkins, G.	Caldwell, Idaho	7
Whitney, B. S.	Beaver, Okla.	10
Yomi, K.	Nagonoken, Japan	1
Total		79

This annual report is closed, as always, by a cordial invitation to every one, amateur or professional, interested in observational astronomy, to write for information about the American Meteor Society with a view to joining in its work.

Flower Observatory, University of Pennsylvania,
Upper Darby, Pa., 1929 February 19.

NOTES FROM AMATEURS.

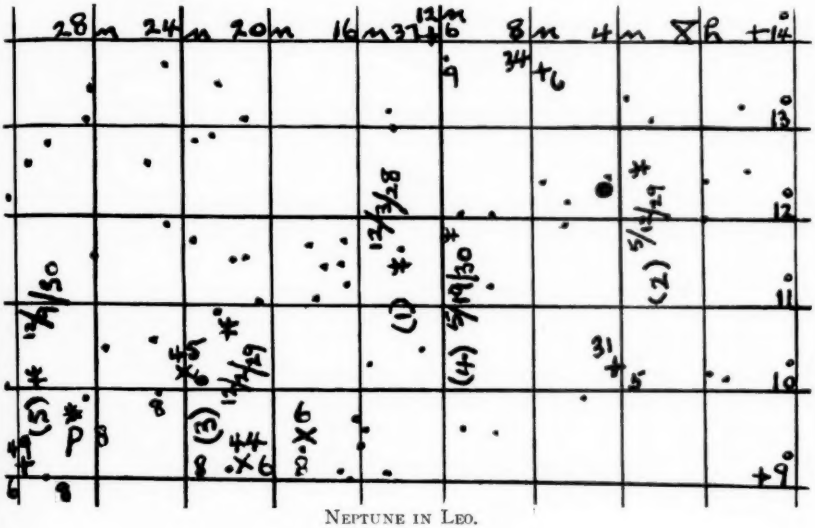
Observations of Mercury and Neptune by an Amateur Astronomer.—Were the amateur astronomer influenced solely by textbooks he would banish from the category of astronomical objects, which he hoped to become acquainted with, Mercury, Uranus, and Neptune—especially Neptune.

Notwithstanding the textbook proscription of these most alluring members of our solar system, it has been the writer's chief astronomical hobby for a number of years to keep up an intimate acquaintance with Mercury, Uranus, and Neptune at their recurrent returns to positions favorable for observation.

As an offset to the textbook damper, it may be that my experiences in following Neptune and Mercury for the past few years with the modest equipment of a Zeiss 15 power 60 mm prism monocular may be of interest to readers of POPULAR ASTRONOMY and encourage amateurs to try their skill in picking up these most romantic members of our solar system.

My procedure is to plot the location of Neptune for the several years to come from information found in the *American Ephemeris*. The accompanying diagram covers the star field in Leo in which Neptune will be up to December, 1930. I then familiarize myself with the characteristic groupings of this star field, which is not a difficult task as it comprises only 8° in right ascension, while my monocular covers a field of 3°. The stars in this field are of the 7th, 8th, and 9th mag., and as Neptune is of 7.7 mag. its presence is readily perceived. As a matter of fact, I roughly calculate the area Neptune will traverse during the following year and I sketch in my own star field, and in the interval before Neptune's return to the morning sky, I check up my sketch with a star atlas. This enables me to identify Neptune almost at my first observation on its return.

I can assure the amateur who tries it that it is not as Mercutio would say: "You will seek all night e'er you find it, and having found it, discover that it is not worth the search." Rather there will have been created one more inspiring astronomical bond across the remoteness of space.



NEPTUNE IN LEO.

What I would especially emphasize is the great advantage a high power monocular or binocular (which must not be smaller than 15 power 60 mm for Neptune) with its large 3° field has over the ordinary telescope with its field of about 1°. I believe this is the reason why most textbooks consider Neptune too difficult for the equipment of the amateur. The fault, however, is with the equipment. It is my opinion that the large field, high power monocular or binocular should enable an amateur with limited technical equipment to locate astronomical objects that would be hopeless in the restricted, small telescope field. I understand Skjellerup's magnificent achievements have been with high power monoculars or binoculars. Of course, these can go up to 3" and 4" with their short focal length and wide field and comparatively low powers.

In POPULAR ASTRONOMY for June-July, 1928, there appeared an article by Mr. R. J. A. Barnard describing the more favorable conditions for observations of Mercury in the southern latitude of Melbourne. My experience observing Mercury in the heart of New York City, with the skyscrapers of lower Manhattan as an horizon may also be of interest and indicate that, with intelligent effort, observing Mercury is not so futile an undertaking as some textbooks would have us believe.

My method with Mercury is to work out the differences in right ascension between Mercury and the sun about fifteen days before greatest elongation and approximate the angles, and determine whether Mercury is north or south of the sun. I never worry about confusing Mercury with a star, for I have found that

at favorable aspects it flashes in my monocular in the bright sunlit sky with a silvery radiance all its own, becoming golden as twilight wanes. Nor do clouds or haze deter my trusty monocular as Mercury gleams through the rifts in a glorious hide and seek.

On the first evening (or morning) that I look for it, just as soon as the sun dips behind the buildings in the west I begin to sweep the sunlit sky at what I judge to be its altitude, and it is a rare astronomical thrill when it inevitably flashes its silvery radiance in my monocular after a series of patient sweeps. I then bring my glass down to a point on my horizon which I use as a marker, and from then on I can pick it up any time (making allowance for its movement) until it reaches greatest elongation and returns again too close to the sun for observation.

Naked-eye views, of course, are few and brief, but there is nothing more beautiful in nature than what I call a perfect Mercury twilight, when it can easily be seen with the naked eye,—those rare occasions when the atmosphere becomes crystal clear and Mercury gleams low down in the sun glow of the western sky with the golden splendour of a promised land,—"and life's realities become all romance." (Goethe).

ELISHA E. COCKEFAIR.

351 Adelphic St., Borough of Brooklyn, New York City, Jan. 10, 1929.

Observation of Jupiter on November 8, 1928. — On the evening of November 8 last, I obtained a most beautiful view of Jupiter and a transit of satellite III. I was using my 6-inch reflector with a power of 255x. There was considerable wind from the northwest and the temperature was falling, yet the

DRAWING SHOWING TRANSIT OF SATELLITE III, NOVEMBER 8, 1928.

"seeing" was remarkably fine. In fact, I felt that I had indeed been privileged to witness such a glorious sight with my humble means.

The markings on the planet were more distinct than I have ever seen them, even in large telescopes. The entire southern hemisphere appeared much darker than the northern, although the north equatorial belt was very dark, and between it and the north polar regions were many fine dark stripes. The cloud-like structure of the southern belt formed an interesting contrast to the continuous appearance of the northern belt. These markings seemed to vary from a light gray to a dark brown or chocolate color.

The little moon was visible as a brilliant white spot during the entire period of transit, which took place across the extreme southern portion of the disk. The general dark tone of the southern polar regions of the planet was brought out by

contrast with the dazzling appearance of the satellite. Yet, during the transit of the shadow, which followed the satellite at a distance of about ⅔ the width of the disk at this latitude, the planet seemed bright in contrast with the absolute blackness of the shadow. In watching the shadow I could not but wonder why it changed apparently not at all in either color or outline in traversing what must be banks of clouds at very different elevations.

While the definition was remarkably good all the evening, the outline of the satellite's disk was more distinct and "hard" just after it had swung clear of the limb than later when it was well out in the sky.

HUGH G. BOUTELL.

3723 Jocelyn St., Washington, D. C.

GENERAL NOTES.

In order to finish the "Reports of Observatories" in this issue it was found necessary to print an extra sixteen-page form. This concludes the material to be included in the Report of the Fortieth Meeting of the American Astronomical Society. In the next issue we shall begin the Report of the Forty-first Meeting, held in New York City last December. The next issue will contain also a further paper by Professor William H. Pickering on "The Orbit of Saturn," and Part VI of Mr. D. B. Pickering's series on "The Astronomical Fraternity of the World."

Professor Robert A. Millikan, director of the Norman Bridge Laboratory of Physics, Pasadena, was unanimously elected president of the American Association for the Advancement of Science for 1929, at the meeting of the council in New York City on December 29, 1928.

Professor Harlow Shapley was elected vice-president of Section D (astronomy) of the American Association for the Advancement of Science at the meeting in New York City last December. Professor Philip Fox was re-elected as secretary of the Section.

Professor A. A. Michelson, of the University of Chicago, and Dr. R. A. Millikan, of the California Institute of Technology, will receive the gold medals of the Society of Arts and Sciences at a dinner at the Biltmore Hotel, New York, on February 22. The medals have been awarded for distinguished service in science. Mr. Gerard Swope will be toastmaster and the speakers will include a number of scientific men and industrial leaders. (*Science,* February 8, 1929.)

Professor Frank Schlesinger, director of the Observatory of Yale University, was one of nine persons to receive a special grant from the American Association for the Advancement of Science, for research in 1929. Dr. Schlesinger will use this grant in furthering the program of determining trigonometric parallaxes of southern stars.

Dr. William H. Wright, astronomer of the Lick Observatory, University of California, has been awarded the Janssen gold medal of the Paris Academy of Sciences for his studies of the atmosphere of Mars and other planets. (*Science,* February 1, 1929.)

Professor Ejnar Hertzsprung, of the Leyden Observatory, has been awarded the gold medal of the Royal Astronomical Society, London, for his work in stellar astronomy. (*Science*, February 15, 1929.)

Dr. W. J. Humphreys, of the U. S. Weather Bureau, has been elected a corresponding member of the Meteorological Society of Hungary. (*Science*, February 15, 1929.)

Professor E. A. Milne, of Oxford University, England, whose work in stellar physics is well known to our readers, will deliver a course of lectures in the 1929 Summer Session of the University of Michigan at Ann Arbor, beginning June 24. The course will be given under the name, "The Physics of the Stars." A popular lecture on "Star Ranging" will also be given by Professor Milne during his residence in Ann Arbor this summer.

Dr. Knut Emil Lundmark, a member of the staff of the Observatory at Upsala, has been appointed Professor of Astronomy in the University and Director of the Observatory at Lund as the successor to Professor C. V. L. Charlier, who has retired from the active duties connected with this position. This is an appointment under the Swedish government. (*Astronomische Nachrichten*, January 21, 1929.)

Professor Harlan T. Stetson, director of the Astronomical Laboratory of Harvard University, was in residence at Carleton College as the Harvard Exchange Lecturer from January 29 to February 15. During his visit Professor Stetson gave a series of lectures on "The Development of Astronomical Thought." These lectures were enthusiastically received by the students in astronomy and by others as well. Professor Stetson's itinerary as Harvard Exchange Lecturer includes Knox College and Pomona College also.

Professor H. Vogt, of the Königstuhl Observatory, Heidelberg, has been called as director of the Observatory and as professor of astronomy at the University in Jena, Germany, the appointment beginning February 1, 1929. (*A.N.*, January 29, 1929.)

Professor Alexander W. Bickerton died in London on January 23 at the age of eighty-seven. Professor Bickerton announced certain theories relating to stellar evolution while he was a professor in New Zealand University, which were then regarded as "unsound science," and which led to the severing of his connections with that University. Last year he was reinstated and given the title of Professor Emeritus.

Leslie C. Beard, Hagerstown, Maryland, writer of non-technical astronomical articles for the newspapers, who has been giving talks on the stars to Boy Scouts and Girl Scouts, gave an address on "The New Astronomy" before the Monarch Club at a luncheon given at the Dagmar Hotel in Hagerstown on February 7. During the lecture he showed a number of pictures from photographs and drawings of the heavenly bodies, many of which were taken from POPULAR ASTRONOMY.

Swarthmore College Eclipse Expedition to Sumatra.—Dr. and Mrs. John A. Miller of Sproul Observatory, their grandson, Larry Miller of New York, Dr. Heber D. Curtis of Allegheny Observatory, Mr. Walter Robinson, a student at Swarthmore, and Mr. J. H. Dugan of Norristown, Pennsylvania, sailed

on January 19, 1929, on the *Laurentic* for Genoa. On February 8 they left Genoa on the S.S. *P. C. Hooft* for Sumatra where they expect to land on February 28.

Dr. and Mrs. Ross W. Marriott and daughter, Alice Elizabeth, have started westward. They sailed from San Francisco on February 12, on the Dollar Liner, *President Garfield,* and will reach Sumatra about the middle of March.

The final choice of station for observing the eclipse will not be made until Dr. Miller has inspected several of the most promising sites.

Harvard Eclipse Expedition.—The Harvard Eclipse Expedition under the direction of Professor Harlan T. Stetson will sail on the S.S. *President Wilson,* of the Dollar Steamship Line, from San Francisco, March 22, for Panang. The party will there disembark and proceed by rail to Alor Star, Capital of the Province of Kedah (Maylay Peninsula) to observe the eclipse of May 9, 1929. Accompanying Professor Stetson will be Mr. and Mrs. Weld Arnold of the American Geographical Society, New York, and Mr. Josef Johnson of the California Institute of Technology.

The expedition will confine itself to photometric work. The outfit will consist of a Macbeth Electric Illuminator and a King Coronal Photometer, the same as was used in the photometric work of the Harvard expedition to Sumatra in 1926. It is planned to measure not only the total sky illumination and determine the light curve throughout the entire eclipse, but also to measure the absolute brightness and the color index of the Corona for comparison with the results of previous eclipses. In addition to this the expedition is equipped with a variety of lenses, one with a ratio of F 1.9 for the rapid photography of the outer reaches of the Corona. A photometric study of the Zodiacal Light will also be undertaken with a view to discovering any possible relation in the distribution of light in the outer stretches of the Corona with the light presumably reflected from the particles composing the Zodiacal Light. This, as far as is known, has not been attempted at any eclipse previously, particularly as regards quantitative measurements. A complete outfit for the photometric standardization of all plates used will be a part of the equipment. In addition, a Debrie Camera will be used for a complete cinemagraphic record of changes in illumination in the Corona and sky throughout the progress of the eclipse.

The party will return by way of the Suez Canal, Mediterranean, and the Atlantic and is expected to arrive in New York the end of June.

Reductions of Occultations Observed During 1928 at Leonia, New Jersey. — The observations were made at my observatory, Lat. 40° 51′ 50″ N, Long. 73° 59′ 19″ W, with a 4-inch Clark refractor, stop watch, and Frodsham chronometer. Error and rate of time piece determined by Arlington time signals. Formulas used in the reductions are those by R. T. A. Innes, *Ast. Jour.,* No. 835, as modified by the Yale University Observatory.

No.	Star	Stars R.A. h m s	Stars Dec. ° ′ ″	Limb	G.C.T. 1928	Immersion h m s	$\chi - \rho$ ° ′	$\sigma' - \sigma$ ″
1	38 Ari	2 41 1.31	+12 8 34.7	D	Jan. 30	0 47 47.0	+ 2 57	—0.1
2	52 B. Gem	6 33 2.87	+24 39 9.3	D	Feb. 2	22 50 20.3	—19 6	—1.7
3	ϕ Sgr	18 41 11.36	—27 4 3.1	D	Sept. 22	23 4 41.8	+14 17	—4.0
4	56 B. Cap	20 35 57.36	—24 2 14.0	D	Sept. 25	2 8 4.0	—18 21	—1.3
5	103 Tau	5 3 46.88	+24 10 25.4	B	Nov. 28	3 40 41.6	—48 44	—0.3
6	τ Tau	4 37 59.11	+22 49 24.3	D	Dec. 25	7 10 14.6	— 0 55	—1.7
7	η Leo	10 3 27.77	+17 6 35.7	B	Dec. 30	8 6 0.9	— 6 38	—3.4

Leonia, New Jersey, January 25, 1929. J. ERNEST G. YALDEN.

Royal Photographic Society Exhibit.—The seventy-fourth annual exhibition of the Royal Photographic Society of Great Britain will be held this year from September 14 to October 14. The secretary wishes a strong American representation, since active support from representative scientific workers in this country contributes largely to the success of the exhibition.

Exhibits intended for the scientific section may be sent to Alexander Murray, Eastman Kodak Co., Rochester, N. Y., and should reach him not later than July 15.

Summary of Sun Spot Observations at Mount Holyoke College, 1928.

Month	No. of Obs.	North of Equator No. of Groups	North of Equator Av. Lat.	South of Equator No. of Groups	South of Equator Av. Lat.	Av. No. at one Obs.	New Groups
January	20	9	+16°6	9	−12°8	3.90	18
February	17	7	16.6	12	11.9	4.88	16
March	15	6	15.5	10	12.8	5.00	11
April	19	9	14.3	15	15.7	5.53	24
May	18	8	10.6	10	14.8	4.89	12
June	9	7	11.3	7	11.6	3.44	7
September	11	6	11.8	5	13.5	4.73	11
October	20	16	15.6	11	11.7	4.10	23
November	17	13	16.5	9	12.6	4.64	16
December	11	7	+17.4	6	−10.8	5.36	13
	157	88		94			151

Average number at one observation	4.66
Average latitude of groups north of equator	+14°86
Average latitude of groups south of equator	−13°03
Number of days observed without spots	0

The observations were made largely by Miss Catherine Stillman and Miss Laura Ewalt.

ALICE H. FARNSWORTH.

John Payson Williston Observatory.

Astronomical Information of Practical Value.—I wish to give you a peculiar and striking proof of the usefulness of the teaching of astronomy in ordinary schools as it might provide a topic to be appreciated later on by many who have occasion to visit the tropics. Some years ago a fellow-countryman of mine went on a shooting party in the jungle of middle Sumatra (Dutch East Indies). It was in the beginning of the month of June. During the hunting he lost touch with the others and suddenly realized that he was lost and did not know where to go. He knew that the general direction in which he had to go to reach open country and the coast (which was close) was west.

So he noted the time and the direction of the shadows and waited until noon. Having been born and educated in Holland he then reasoned that at noon the sun was due *south* and therefore, facing it, east would be to his left, west to his right. After thus determining this west direction he set off, carefully marking his way and only after ten days, in an extremely exhausted condition from which it took him a long time to recover, reached a tobacco plantation. The finding of this plantation was by the merest accident, one chance in a thousand.

He did not realize that, being practically on the equator and in June, the sun must be in the *north*, and that in fact he marched east instead of west. After several hours walking he grew desperate, lost his markings and then probably walked in left hand circles as one is wont to do.

In my opinion this is a good instance showing the usefulness of the first principles of astronomy to be made clear to everybody.

Tanakan, Dutch East Indies. D. VAN NYNIEGEN VOHONEGEVEL.

Zodiacal Light Observations.

Morning Observations. On September 17, 1928, Mr. Oscar E. Monnig, Fort Worth, Texas, at 5:00 A.M. under excellent atmospheric conditions found the apex of the Zodiacal Light a few degrees north of γ Geminorum, thence the northern boundary extended to κ Geminorum and on to ξ Leonis. The southern boundary passed about 1° south of λ Geminorum and just north of the Hydra's head. "The brightness compared well with that of the Milky Way (in Taurus) and, if anything, excelled it." On November 11 at 5:00 A.M. the apex was seen about 3° beyond Praesepe; the northern boundary passed δ Leonis and α Comae Berenices to the horizon, the southern boundary was about 3° south of Regulus and passed thence to 5° south of γ Virginis. The axis of the Light was well north of the ecliptic.

Evening Observations. Mr. Sterling Bunch, Fort Worth, Texas, reported two evening observations, one on January 12, 1928, at 7:30 P.M., and one on February 18, 1928, at 8:00 P.M. With a rating of 1.0 for the brightness of the Milky Way from Cassiopeia through Cygnus he assigned to the Zodiacal Light for the January observation a rating of 1.5 and for the February observation a rating of 2.0. Color, yellowish white.

Gegenschein Observations. On October 7, 1928, Mr. Monnig observed the Gegenschein and found that "there was no difficulty in locating it, but the illumination was of such a vague quality that estimates of dimensions were chiefly guesswork. Maximum dimensions of the axes I would place at 8° and 6°. It seemed to envelop the little curve of three stars in Pisces formed by δ, ϵ, and ξ." The same night at midnight Mr. Bunch saw it as "an elliptical diffused nebulosity possibly 10° in length by three-fourths as wide, about one-fourth as bright as the Milky Way in Taurus." On October 17 at 3:00 A.M. Mr. Bunch again observed the Gegenschein but could do no more than locate the center of luminosity in Aries. He was more successful on November 10 when at 11:00 P.M. he saw it in Taurus a few degrees west of the Pleiades. "Zodiacal band was easily seen from western horizon to Milky Way. Later the band could be seen from horizon to horizon with the Gegenschein as a broadening of the band."

Evening Observations, 1929. On January 6 at 7:00 P.M. the writer found the apex of the Zodiacal Light slightly north of Jupiter in Aries. Venus was south of the median line. On the horizon the Zodiacal Light and the Milky Way approached each other so as to suggest an acute angle with a conspicuously dark area between. At 10:00 P.M. the western Zodiacal Light was still visible and on looking along the ecliptic past Gemini to the eastern horizon a Zodiacal band was plainly visible through Praesepe to Leo. On January 8 at 7:45 the boundaries of the Zodiacal Light were not clear; in fact, the whole Light was fainter than on January 6. On the same evening an aurora at 7:30 showed as an unbroken arch from Vega low in the northwest through the handle of the Big Dipper down to the horizon in the northeast. At 7:40 the arch broke up, pulsations were noticed and the Light became diffused along the horizon obscured by clouds.

A report of the Zodiacal Light apparition seen skirting the northern horizon during midsummer at midnight has come from Russia where at midnight on June

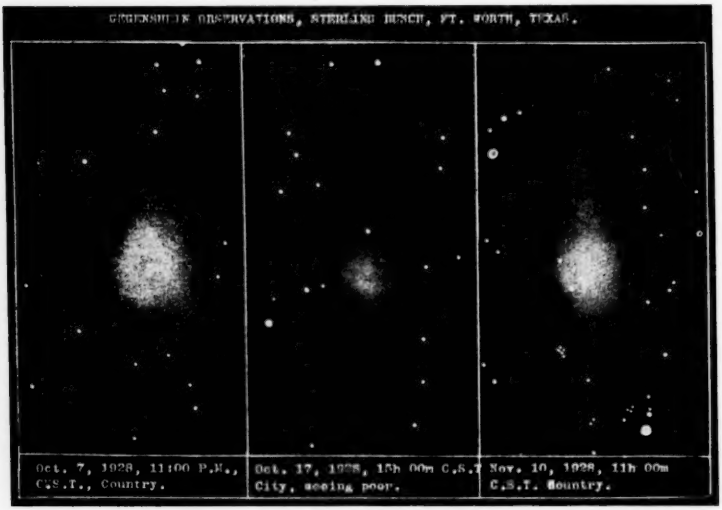
25, 26, and 28, 1927, Professor G. Zacharow made observations from Mt. Tschatyr-Dagh, lat. 44° 45′ N., long. 34° 25′ E., 1523 m. above sea level. Professor Zacharow found that the apparition extended 45° from the sun as compared with similar observations made by Professor Newcomb in 1905 (35°) and Dr. E. A. Fath in 1907 (42°). Dr. S. G. Barton calls attention to the latest book on Zodiacal Light, published at Hamburg last year. It is a book of 128 pages, entitled "Das Zodiakallicht" by Dr. H. C. Friedrich Schmid.

W. E. GLANVILLE.

The Rectory, New Market, Maryland.

SPECIAL NOTE.

A Novel Method of Illustrating Observation Reports. Mr. Sterling Bunch, Fort Worth, Texas, sends the following description: "The method of reproducing Zodiacal Light and Gegenschein pictures is as follows: A plot of the region covered is made on white paper with the stars as black dots. We use the A.M.S. maps because the projection is good. The phenomenon is then shaded in by blackening the fingertip with lead pencil shavings and rubbing it lightly on the paper.


GEGENSCHEIN OBSERVATIONS, STERLING BUNCH, FT. WORTH, TEXAS.
Oct. 7, 1928, 11:00 P.M., C.S.T., Country.
Oct. 17, 1928, 15h 00m C.S.T. City, seeing poor.
Nov. 10, 1928, 11h 00m C.S.T. Country.

If a little care is exercised the proper intensity may be had. When the drawing is finished it is then photostated in opposite contrast, which is the first print made in the photostatic process. The result is a dark sky with the stars and the Zodiacal Light or Gegenschein, as shown in the accompanying illustration. I believe that the idea is worth passing on to other observers."

Color Change Preceding Occultation of Sigma Sagittarii.— On July 2, I observed the occultation of Sigma Sagittarii with my 6-inch reflecting telescope, power 55X. Upon first examining the star, the moon then not being in the field of view, its color appeared to be white or bluish. As the star approached closer to the moon and as more of the moon's bright face appeared in

the field, the star gradually changed color until, when close to the bright limb and perhaps one minute before immersion, it shone with a brilliant emerald green. I have never before noticed such a pronounced change in color when observing an occultation with either a reflector or refractor, though doubtless it is common enough. It must have been the result of contrast or perhaps some peculiar atmospheric effect.

This occultation was an unusually beautiful one. The "seeing" was excellent, and fortunately the moon was well clear of obstructions, which is not always the case at my "observatory."

I noted another interesting and altogether different change in color on the night of September 8, when observing an eclipse of Jupiter's third satellite with my 2¾-inch refractor, power 150X. In addition to the usual gradual extinction of the light, occupying several seconds, the tiny disk changed color from a golden yellow to a dusky red. The color, just before the little moon disappeared entirely, was similar to that of our moon at the time of a lunar eclipse. The satellite was distant from the planet about two-thirds of a diameter.

[NOTE: Unfortunately the name of the writer of this item became separated from the item. Nevertheless, it seemed to be of such importance that we are publishing it here. If it comes to the attention of the writer, possibly he will be kind enough to communicate with us.]

BOOK REVIEWS.

Grundriss der Astrophysik by K. Graff. (B. G. Teubner, Leipzig, 1928, 750 pp. Price 45 marks.)

The general field of astrophysics is expanding so rapidly that it is well-nigh impossible for the average person interested in astronomy to keep up with the march of progress. Almost daily new results are being added to our fund of observational material and new theories are being developed constantly. This work by Professor Graff should prove to be of great assistance to all who wish to keep abreast of the times in the field of astrophysics. It contains material available to approximately the end of 1927. While the subject as a whole is technical, yet the author has succeeded in presenting it with a minimum of mathematical development. The style is clear. Over 400 illustrations are used in the text besides a number of full-page plates. The first part of the volume is devoted to "The scientific foundations of astrophysical investigation." This requires over 250 pages in which fundamental physical concepts, celestial photography, spectroscopy and photometry are discussed. The second part of about 220 pages is devoted to the solar system and the third part to the stars, star clusters and nebulae. References to the more important original sources are given in the foot-notes. The index of names and subjects covers 24 pages. The book can be recommended as the best of its kind now available. It deserves a place in every astronomical library.

—E. A. F.

A Manual of Laboratory Astronomy, by Harlan True Stetson in collaboration with John C. Duncan. (Eastern Science Supply Co.)

Astronomy is gradually regaining its former place in the curricula of the colleges and universities of the country after having suffered a partial eclipse by the claims made by biology, chemistry, and physics. The past generation of astrono-

mers was well trained in the mathematical developments of astronomy and these aspects so dominated their teaching that only the student with adequate mathematical training could follow the courses to advantage. The reaction against mathematics reduced the number of students of elementary astronomy to a minimum. The laboratory methods of the other sciences gradually worked their way into the teaching of astronomy until now the term "astronomical laboratory" is becoming almost as familiar as the term "astronomical observatory." For those teachers of astronomy who are willing to adopt the newer methods the new edition of the Stetson-Duncan laboratory manual will be found to be of the greatest help not only in teaching the essential facts about the science but also in developing good methods of observing and drawing conclusions from the data obtained.

The new edition is well printed, neatly bound and the changes and additions made in the material add to its value. The Eastern Science Supply Co. deserves much credit for the well-made laboratory equipment it is placing on the market and the use of this equipment in connection with the exercises of the new manual makes it possible for any institution to give satisfactory courses in elementary astronomy. —E. A. F.

Source Book in Astronomy, by Harlow Shapley and Helen E. Howarth. (McGraw-Hill Book Co., New York City. 405 pages, $4.00.)

It is entirely fitting that the source book in astronomy, the oldest of the sciences, should be the first to appear in the proposed series of Source Books in the History of the Sciences. (The series is to consist of eight or ten volumes under the general editorship of Professor Gregory D. Walcott.) It is also very fitting that such a book should appear at a time when there is an awakened interest in astronomy, and when the work of the pioneers in this science is being re-evaluated in the light of recent developments and discoveries.

Perhaps the best way to indicate the scope of this volume in the space allotted to this review is to give a catalogue of the names of those from whose work the volume is made up. The period covered is from the Renaissance to the end of the nineteenth century. The work of astronomers now living is not considered. Quotations, in the main in chronological order, are made from Copernicus, Tycho Brahe, Bayer, Kepler, Galileo, Horrox, Huygens, Roemer, Cassini, Newton, Flamsteed, Halley, Bradley, Thomas Wright, Kant, Lambert, Lagrange, Maskelyne, Sir William Herschel, Goodricke, Laplace, Olbers, Bode and Piazzi, Gauss, Fraunhofer, Airy, F. G. W. Struve, Bessel, Schwabe, Humbolt, Argelander, John Herschel, Adams, Leverrier, Rosse, Kelvin, George P. Bond, Carrington, Maxwell, Kirchhoff, Foucault, Herbert Spencer, Sir William Huggins, Secchi, Kirkwood, Janssen, Helmholz, Young, Asaph Hall, Gould, Newcomb, Langley, Kapteyn and Gill, Lockyer, Bredikhine, G. W. Hill, E. C. Pickering, Chandler, Schiaparelli, Lowell, Keeler, and G. H. Darwin, a total of sixty-four persons. In addition there is an interesting quotation from that part of the will of James Lick which provides for the construction of the Lick Observatory. There are also numerous plates and diagrams which add to its interest and value.

From some points of view this is one of the most important among the books in astronomy issued recently. It is unnecessary to say that this book should be in every library for, in a very real sense, there is a library in this book.